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SOME NEW FACTS RELATING TO THE EFFECT OF METERS ON THE CONSUMPTION OF WATER.

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[*Read March 13, 1907.*]

For the past twenty years the advantages of selling water by meter have been much discussed, until now there are but few connected with the management of water works who question the desirability of having all services metered. There is much yet to be learned, however, as to the results to be accomplished. The enormous saving of water, and the consequent saving in expense which would be possible by the general use of meters, have been repeatedly demonstrated. The cities of Brockton, Fall River, and Providence, where meters have been in general use for many years, have been referred to time and time again as examples of what might be accomplished in other places. The English and German cities, with their still lower consumption, have also been frequently cited as examples of what ought to be accomplished in American cities.

During the past ten to twenty years great numbers of meters have been introduced, and now in many places the percentage of metered services is as great as in the cities which have so long served as examples, — but the predicted saving in water has not been accomplished. On the contrary, an examination of the figures of consumption shows that the rate of increase in the use of water in Brockton, Fall River, and Providence is greater than the rate

of decrease in many of the places where meters have recently been introduced, indicating that if the consumption in these other cities ever becomes the same as that of Brockton, Fall River, and Providence, the latter places are likely to meet the others half way.

Notwithstanding the great increase in the use of meters all over the country, the average quantity of water consumed per person is increasing at a rapid rate. The increase in the consumption of water during the past ten years is shown in the accompanying diagram, Fig. 1, which gives the average daily consumption in a large number of cities outside of New England and in the principal New England cities and towns. On the same diagram is shown the consumption of water in those places inside and outside of New England where, in 1895, at the beginning of the period, more than 25 per cent. of the services were metered, and the consumption in those places where the percentage of metered services has increased more than 25 during the ten years, — that is, where there has been a general introduction of meters.

We are struck, in the first place, by the great difference in the consumption of water in New England and in the cities outside of New England. This creditable showing we will explain as being due to the influence of the New England Water Works Association.

The startling feature of the diagram, however, is the apparent failure of meters to reduce the consumption of water, or even to check the increase. During this period of ten years there were installed in the places used in making these curves more than 250 000 meters. In the places used in making the averages outside of New England the percentage of metered services in 1895 was 13, while in 1905, at the end of the ten years, it had increased to 38. During this time there was an increase in the per capita consumption of water amounting to 11 gallons per day. In New England the percentage of metered services in 1895 was 40, increasing in the ten years to 60, while the consumption increased 15 gallons per person per day.

In those places outside of New England where more than 25 per cent. of the services were metered at the beginning of the period under consideration, the increase has been 14 gallons per day. In those places where there has been a very general introduction of meters during the period there has been a decrease of 1 gallon per

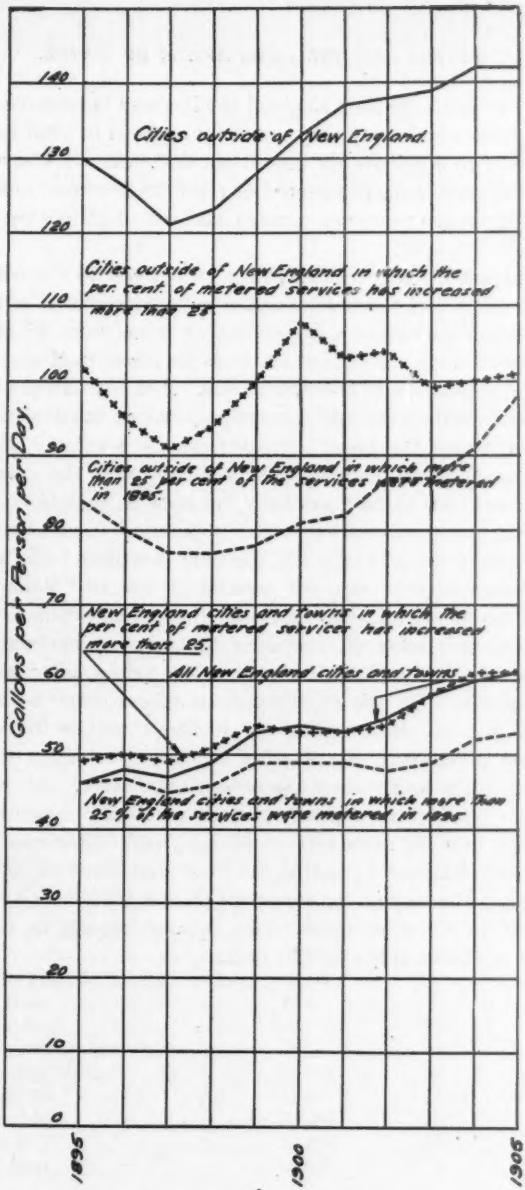

Gallons per Person per Day.
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Cities outside of New England.
Cities outside of New England in which the per cent. of metered services has increased more than 25.
Cities outside of New England in which more than 25 per cent of the services were metered in 1895.
New England cities and towns in which the per cent of metered services has increased more than 25.
All New England cities and towns.
New England cities and towns in which more than 25 % of the services were metered in 1895
1895
1900
1905

FIG. 1.

person per day. In New England the increase in consumption in those places which were very generally metered in 1895 has been kept down to 6 gallons per person per day, while in those places where the percentage of metered services has increased more than 25 during the ten years the increase has been 11 gallons per person per day.

In Table No. 1 are given statistics in relation to the consumption of water and the percentage of metered services, in 1905, in American cities having a population of more than 25 000. In Table No. 2 are given similar statistics for places in Massachusetts having a population of less than 25 000. The population of places in Massachusetts is the 1905 census population; outside of Massachusetts, where the latest available census is that of 1900, the population has been estimated by assuming that the rate of increase from 1900 to 1905 has been the same as that from 1890 to 1900. In practically all cases the population used is the total population of the city supplied, the only exception being where a large community is supplied outside of the city limits. This figure does not in all cases represent the actual population using the water, as in some of the places there is a considerable percentage of the population to which the public water supply is not available. On the other hand, in places used as summer resorts, and in cities which are business centers for the surrounding population, the number of people actually using the water is much larger than the census population. It is found that the estimates of the population actually supplied with water are in many cases very inaccurate, and better comparative results are obtained by taking the total population of the places supplied. The figures for consumption and for meters have been obtained in all cases either from printed reports or from the officials in charge of the water works.

TABLE No. 1.

AVERAGE DAILY CONSUMPTION OF WATER AND PERCENTAGE OF METERED SERVICES IN 1905 IN CITIES HAVING A POPULATION OF MORE THAN 25 000.

City.	Population.	Per Cent. Metered Services.	Consumption. (Gallons per Person per Day.)
Albany, N. Y.	93 765	15	211
Altoona, Pa.	43 291	3	112
Atlanta, Ga.	102 041	100	65
Atlantic City, N. J.	35 229	78	147
Auburn, N. Y.	32 588	6	172
Augusta, Ga.	42 511	0	150
Bay City, Mich.	27 523	33	122
Bayonne, N. J.	39 566	100	95
Boston, Mass.	595 380	5	151
Bridgeport, Conn.	82 061	5	210
Brockton, Mass.	47 794	90	38
Buffalo, N. Y.	400 748	3	324
Butte, Mont.	40 343	7	100
Cambridge, Mass.	97 434	19	92
Camden, N. J.	84 746	3	155
Canton, Ohio	32 906	2	125
Cedar Rapids, Ia.	29 474	40	83
Charleston, S. C.	56 233	2	57
Chelsea, Mass.	37 289	10	110
Chester, Pa.	40 869	20	75
Cincinnati, Ohio	340 399	12	130
Cleveland, Ohio	441 974	68	137
Columbus, Ohio	144 265	76	110
Covington, Ky.	45 721	100	51
Davenport, Ia.	39 445	50	81
Dayton, Ohio	97 389	70	70
Detroit, Mich.	325 614	9	188
Duluth, Minn.	62 896	41	77
Erie, Pa.	58 783	2	179
Evansville, Ind.	63 132	0	125
Everett, Mass.	29 111	2	89
Fall River, Mass.	105 762	97	42
Gloucester, Mass.	26 011	5	53
Grand Rapids, Mich.	101 211	29	123
Harrisburg, Pa.	55 557	73	171
Hartford, Conn.	93 160	98	66
Hoboken, N. J.	67 222	69	115
Holyoke, Mass.	49 934	8	120

City.	Population.	Per Cent. Metered Services.	Consumption. (Gallons per Person per Day.)
Indianapolis, Ind.	196 028	10	82
Jackson, Mich.	27 371	26	74
Jacksonville, Fla.	34 043	59	67
Johnstown, Pa.	43 000	1	159
Kansas City, Kan.	57 969	45	113
Kansas City, Mo.	179 270	38	73
Knoxville, Tenn.	37 688	36	67
La Crosse, Wis.	30 797	5	96
Lancaster, Pa.	46 183	20	130
Lawrence, Mass.	70 050	88	43
Lexington, Ky.	28 770	98	58
Lincoln, Neb.	32 677	100	40
Los Angeles, Cal.	128 521	31	120
Louisville, Ky.	226 531	8	81
Lowell, Mass.	94 889	69	58
Lynn and Saugus, Mass.	83 295	30	59
Malden, Mass.	38 037	78	53
McKeesport, Pa.	40 970	23	115
Manchester, N. H.	63 417	72	52
Memphis, Tenn.	121 232	20	100
Milwaukee, Wis.	325 735	80	91
Minneapolis, Minn.	221 708	47	76
Nashville, Tenn.	283 213	52	148
Newark, N. J.	278 190	44	117
New Bedford, Mass.	74 362	23	95
New Britain, Conn.	30 737	6	145
Newcastle, Pa.	36 708	1	94
New Haven, Conn.	121 391	3	168
Newport, Ky.	29 992	20	37
Newton, Mass.	36 827	86	58
Norfolk, Va.	52 500	0	125
Omaha, Neb.	83 607	59	110
Oshkosh, Wis.	31 008	15	76
Paterson, N. J.	118 583	37	87
Pawtucket, R. I.	79 400	81	104
Philadelphia, Pa.	1 417 063	1	230
Pittsburg, Pa.	363 116	0	210
Providence, R. I.	212 823	86	68
Quincy, Ill.	38 631	53	31
Quincy, Mass.	28 076	3	109
Racine, Wis.	33 146	51	90
Reading, Pa.	89 111	7	128

City.	Population.	Per Cent. Metered Services.	Consumption. (Gallons per Person per Day.)
Richmond, Va.	86 881	44	150
Rochester, N. Y.	176 964	41	88
Rockford, Ill.	34 784	19	95
Saginaw, Mich.	40 357	8	200
St. John, N. B.	45 432	3	143
St. Joseph, Mo.	128 306	20	58
St. Louis, Mo.	636 972	7	92
St. Paul, Minn.	178 020	38	56
Salt Lake City, Utah	57 875	2	309
San Antonio, Tex.	61 145	10	132
San Francisco, Cal.	364 674	21	96
Schenectady, N. Y.	37 572	0	99
Seattle, Wash.	99 588	12	100
Sioux City, Ia.	30 764	61	35
Somerville, Mass.	69 272	19	89
South Bend, Ind.	43 089	8	102
Springfield, Ohio	41 432	12	85
Superior, Wis.	40 645	31	57
Tacoma, Wash.	38 568	10	72
Taunton, Mass.	30 967	46	62
Terre Haute, Ind.	39 901	19	70
Toledo, Ohio	157 015	70	75
Toronto, Can.	270 000	4	93
Troy, N. Y.	60 500	4	248
Utica, N. Y.	62 569	98	59
Waltham, Mass.	26 282	10	79
Wilmington, Del.	84 046	21	102
Woonsocket, R. I.	31 888	85	37
Worcester, Mass.	128 135	95	75
Yonkers, N. Y.	55 879	99	115
York, Pa.	40 165	3	63

TABLE No. 2.

AVERAGE DAILY CONSUMPTION OF WATER AND PERCENTAGE OF METERED SERVICES IN 1905 IN CITIES AND TOWNS IN MASSACHUSETTS HAVING A POPULATION OF LESS THAN 25 000.

City or Town.	Population.	Per Cent. Metered Services.	Consumption. (Gallons per Person per Day.)
Andover	6 632	78	68
Arlington	9 668	22	81
Attleboro	12 702	100	43
Avon	1 901	1	40
Ayer	2 386	55	53
Belmont	4 360	100	61
Beverly	15 223	3	87
Billerica	2 843	59	28
Braintree	6 879	37	87
Bridgewater and East Bridgewater	9 923	9	21
Brookline	23 436	93	95
Canton	4 702	47	63
Clinton	13 105	86	41
Danvers and Middleton	10 131	2	81
Dedham	7 774	37	135
Easton	4 909	43	24
Fairhaven	4 235	45	79
Falmouth	3 241	1	73
Foxboro	3 364	46	63
Franklin	5 244	2	44
Gardner	12 012	6	80
Groton	2 253	99	28
Hyde Park	14 510	34	77
Ipswich	5 205	30	26
Lexington	4 530	2	66
Manchester	2 618	100	94
Mansfield	4 245	33	49
Marlboro	14 073	59	41
Maynard	5 811	78	45
Medford	19 686	8	98
Melrose	14 295	3	112
Merrimac	1 884	100	28
Methuen	8 676	78	43
Middleboro	6 888	47	38
Milford and Hopedale	14 153	19	65
Milton	7 054	100	46
Montague	7 015	4	81

City or Town.	Population.	Per Cent. Metered Services.	Consumption. (Gallons per Person per Day.)
Nahant	922	18	149
Nantucket	2 930	0	56
Natick	9 609	58	56
Needham	4 284	95	66
Newburyport	14 675	2	51
North Andover	4 614	74	43
North Attleboro	7 878	100	40
Norwood	6 731	55	64
Orange	5 578	64	27
Peabody	13 098	4	133
Reading	5 682	89	28
Revere	12 659	4	80
Rockport	4 447	2	81
Shirley	1 692	99	13
Stoneham	6 332	2	81
Stoughton	5 959	59	64
Tisbury	1 120	1	63
Walpole	4 003	47	86
Ware	8 594	100	41
Wareham	3 660	0	10
Watertown	11 258	94	70
Webster	10 018	48	34
Wellesley	6 189	100	47
Weston	2 091	81	31
Whitman	6 521	54	25
Winchendon	5 933	97	18
Winthrop	7 034	2	114
Woburn	14 402	2	103

In order to show the relation between the percentage of metered services and the consumption, Tables No. 3 and No. 4 are presented, giving the average consumption in those places having certain percentages of services metered.

TABLE No. 3.

AVERAGE CONSUMPTION OF WATER PER PERSON IN 1905 IN CITIES HAVING A POPULATION OF MORE THAN 25 000, ARRANGED IN GROUPS ACCORDING TO THE PERCENTAGE OF SERVICES WHICH ARE PROVIDED WITH METERS.

	Gallons per Day.
Average of 34 cities in which not more than 10 per cent. of the services are metered	146
Average of 23 cities in which more than 10 per cent. but less than 25 per cent. of the services are metered	97
Average of 18 cities in which more than 25 per cent. but less than 50 per cent. of the services are metered	89
Average of 14 cities in which more than 50 per cent. but less than 75 per cent. of the services are metered	89
Average of 19 cities in which more than 75 per cent. of the services are metered	72

TABLE No. 4.

AVERAGE CONSUMPTION OF WATER PER PERSON IN 1905 IN CITIES AND TOWNS IN MASSACHUSETTS HAVING A POPULATION OF LESS THAN 25 000, ARRANGED IN GROUPS ACCORDING TO THE PERCENTAGE OF SERVICES WHICH ARE PROVIDED WITH METERS.

	Gallons per Day.
Average of 26 cities and towns in which not more than 25 per cent. of the services are metered	77
Average of 12 cities and towns in which more than 25 per cent. but less than 50 per cent. of the services are metered	63
Average of 9 cities and towns in which more than 50 per cent. but less than 75 per cent. of the services are metered	45
Average of 22 cities and towns in which more than 75 per cent. of the services are metered	48

These tables show that there is a marked difference in the consumption of water in the places which are generally metered and in those places which are not metered, but they also show that the consumption of water in the larger cities, even in places which are generally provided with meters, is much in excess of that in Brockton and Fall River.

The foregoing tables show the consumption in 1905 as compared with the number of meters in use at that time, and include places which have been thoroughly metered for a long period. In many places meters have been generally introduced within a few years, and in order to show the immediate effect of the introduction of

meters Table No. 5 has been prepared, which gives the increase or decrease in the consumption of water as compared with the increase in the percentage of metered services in the period from 1890 to 1905, and in the five years from 1900 to 1905.

TABLE No. 5.

INCREASE IN THE CONSUMPTION OF WATER IN CITIES AND TOWNS DURING THE PERIODS FROM 1890 TO 1905, AND FROM 1900 TO 1905, COMPARED WITH THE INCREASE IN THE PERCENTAGE OF METERED SERVICES DURING THE SAME PERIODS.

Increase in Percentage of Metered Services.	1890 — 1905.		1900 — 1905.	
	Number of Places.	Increase in Consumption. Gallons per Person per Day.	Number of Places.	Increase in Consumption. Gallons per Person per Day.
Less than 10	27	36	95	7
10–25	25	10	33	1
25–50	16	9	12	6*
More than 50	11	14	4	17*

* Decrease.

This table shows the effect of the introduction of a large number of meters within a short period. As would naturally be expected, the immediate effect is a reduction in the quantity of water used; but while the introduction of more than 25 per cent. of metered services within five years reduces the consumption, the introduction of the same number of meters in a period of fifteen years does not prevent a substantial increase in the consumption. In other words, it would appear that after a certain amount of waste has been checked, the increase in the consumption continues notwithstanding the use of meters.

The accompanying diagrams, Figs. 2 to 13, show graphically the relation between the percentage of metered services and the per capita consumption of water in several typical cities. In Figs. 2 to 7 will be seen the increase in consumption in cities which are thoroughly metered, the increase in all cases being very substantial. This increase may be called the normal increase in the consumption with all reasonable precautions taken against waste.

In the case of Richmond, Fig. 8, is shown the effect of the intro-

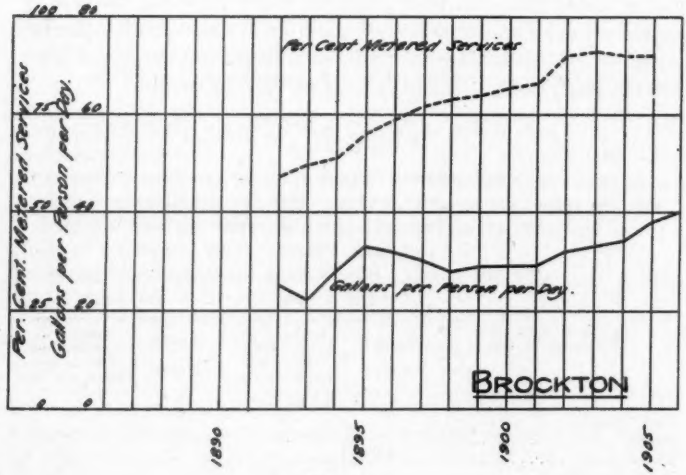

Per Cent. Metered Services
Gallons per Person per Day
Per Cent Metered Services
Gallons per Person per Day.
BROCKTON
1890
1895
1900
1905

FIG. 2.

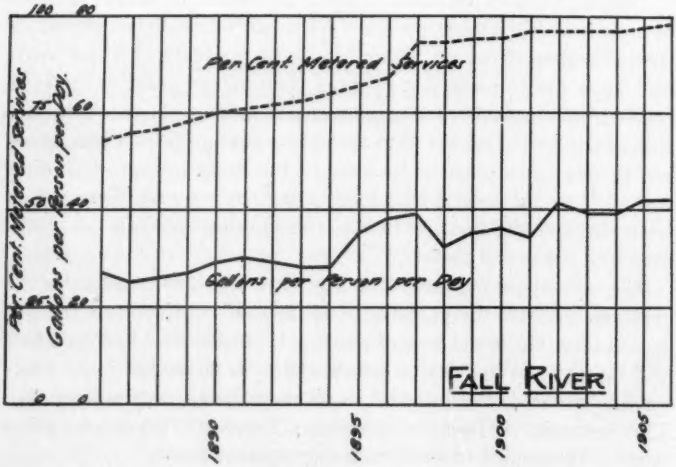

Per Cent. Metered Services
Gallons per Person per Day
Per Cent Metered Services
Gallons per Person per Day
FALL RIVER
1890
1895
1900
1905

FIG. 3.

duction of meters on an abnormally large consumption, and this is a typical diagram. The immediate effect of the introduction of meters in such a place is to make a great reduction in the quantity of water used. The reduction continues for a few years until the principal sources of waste are discontinued, or possibly until the vigilance of the water department is somewhat abated, and then

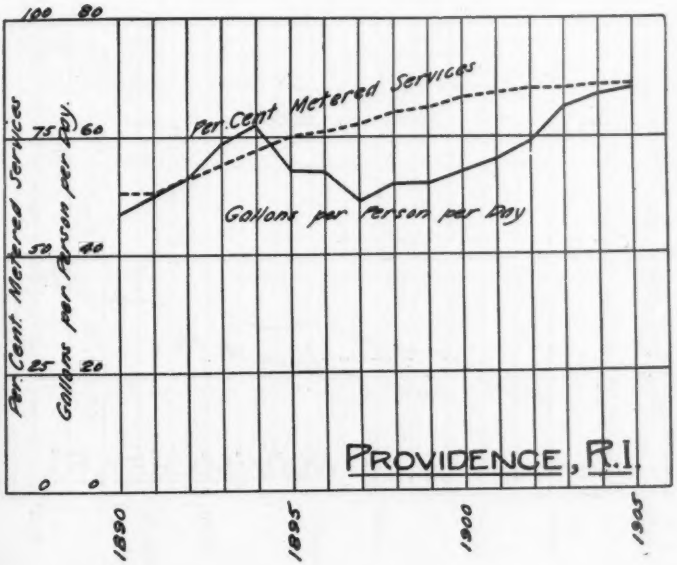


FIG. 4.

the increase in consumption again begins at substantially the same rate as before meters were introduced.

In Needham and Attleboro, Figs. 9 and 10, the introduction of meters appears to have failed to check the increase in the consumption.

The last three diagrams, Figs. 11, 12, and 13, show cases where the effect of meters may be overestimated, as there are other conditions which affect the quantity of water consumed. It is well

known that where the water supply is of poor quality a much greater quantity is used than where the water is clear and colorless, and this is especially the case where the water contains an excessive amount of iron or large numbers of organisms, as faucets are allowed to run for a long time in an attempt to make the water run clear. In the places represented in these diagrams water of poor

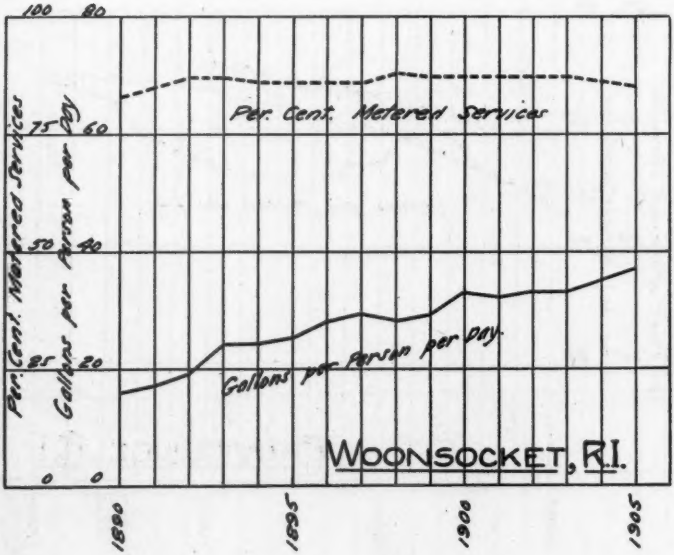


FIG. 5.

quality was supplied up to the time when the reduction in the consumption began. In the case of Reading the water contained such large quantities of iron as to make it practically unfit for any domestic purpose. After the construction of a filter to remove the iron the consumption of water was reduced very materially, and the greatest reduction occurred the year before the general introduction of meters. In Lowell and Lawrence meters were being rapidly introduced for many years before the reduction in

consumption began, and this reduction occurred immediately after the introduction of a better water supply.

It is very dangerous to draw conclusions from individual cases without a knowledge of all of the conditions, but the places in-

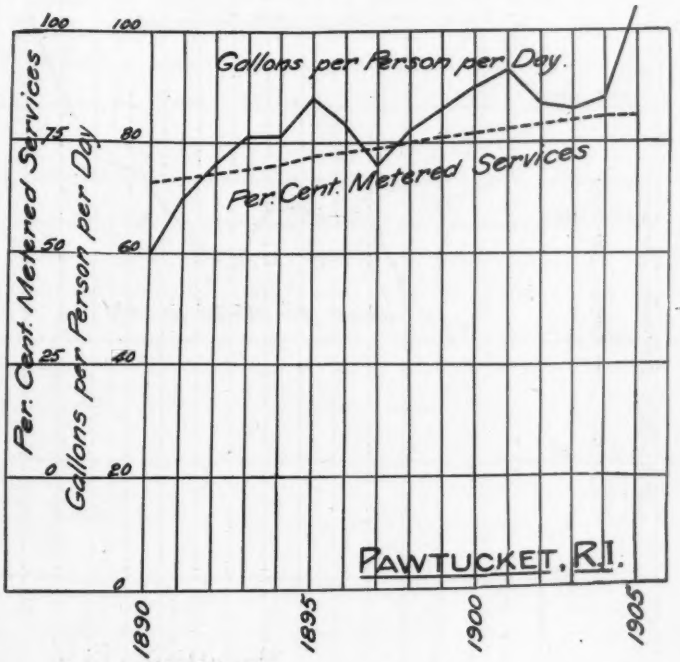


FIG. 6.

cluded in these diagrams are selected because they are typical of a large number of places.

Enough has been shown to indicate that the introduction of meters in places where the consumption of water has been large has not, in most cases, produced the results which have been anticipated. What, then, has been accomplished by meters, and what effect are they likely to have on the consumption of water in the future?

In the consideration of what meters will accomplish, it is convenient to divide the use and waste of water into the following classes:

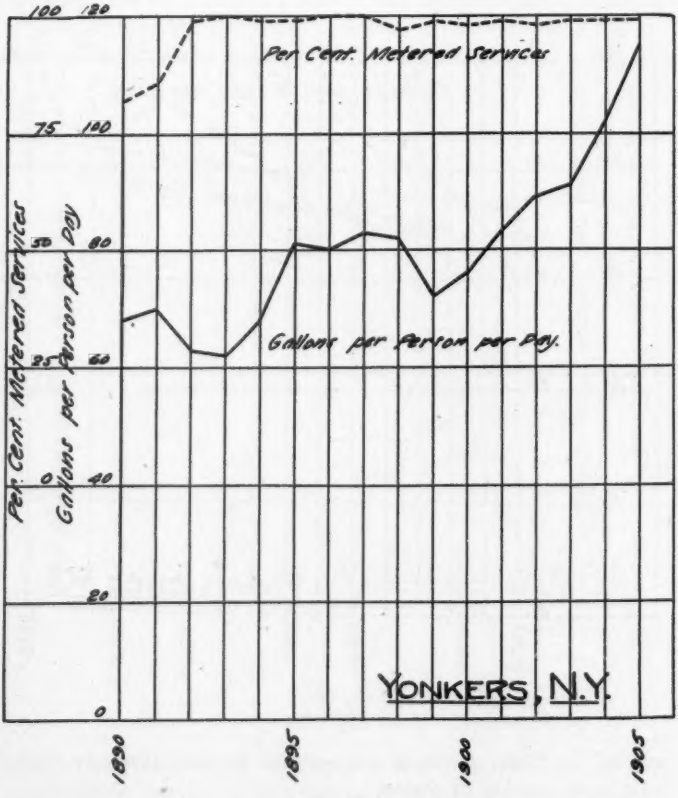


FIG. 7.

1. Water used or wasted in houses.

2. Water used in factories and for mechanical purposes.

3. Water used for public purposes, such as watering streets, supplying drinking fountains, etc.

4. Leakage from street mains, distributing reservoirs, and service pipes.

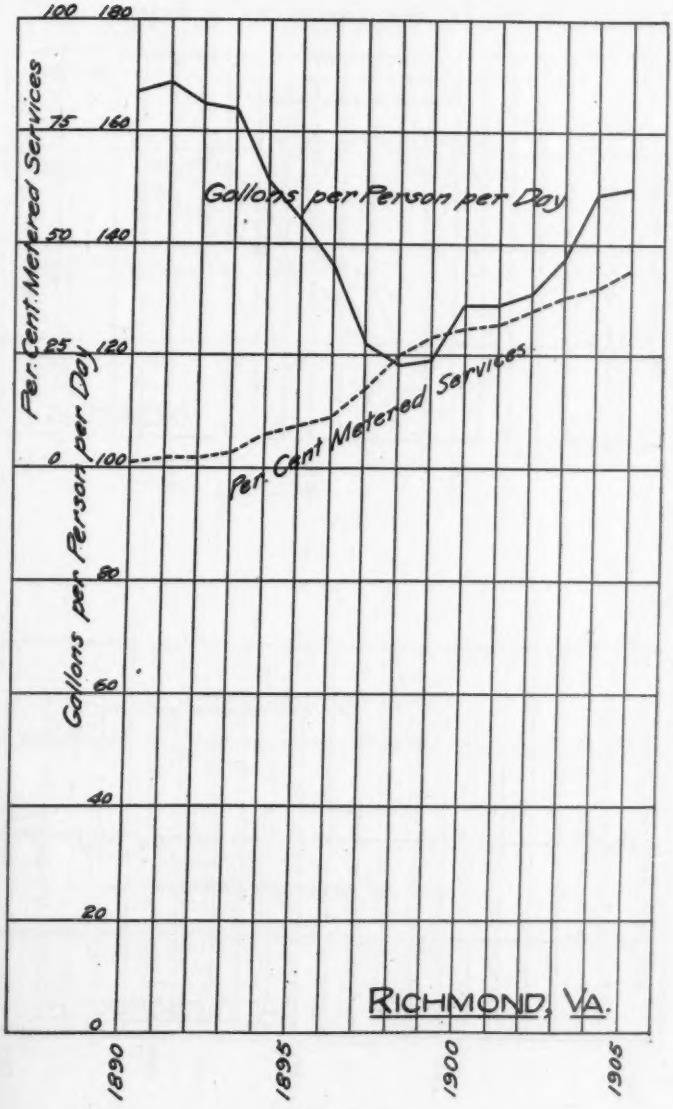

Per. Cent. Metered Services
Gallons per Person per Day
100
75
50
25
0
180
160
140
120
100
80
60
40
20
0
Gallons per Person per Day
Per. Cent Metered Services
RICHMOND, VA.
1890
1895
1900
1905

FIG. 8.

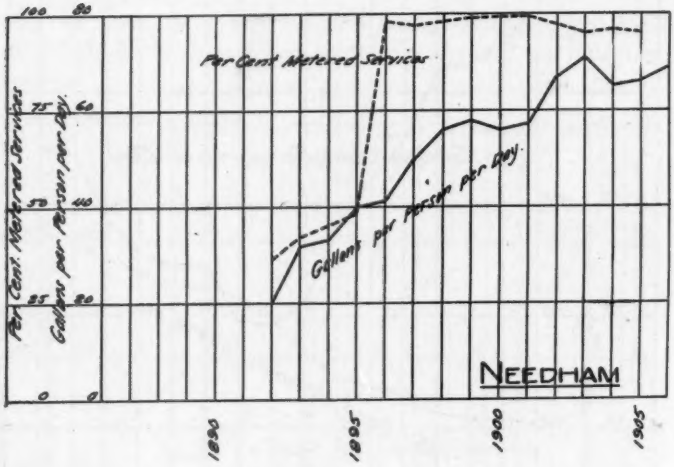

100
80
75
60
50
40
25
20
0
0
Per Cent. Metered Services
Gallons per Person per Day
Per Cent Metered Services
Gallons per Person per Day
NEEDHAM
1890
1895
1900
1905

FIG. 9.

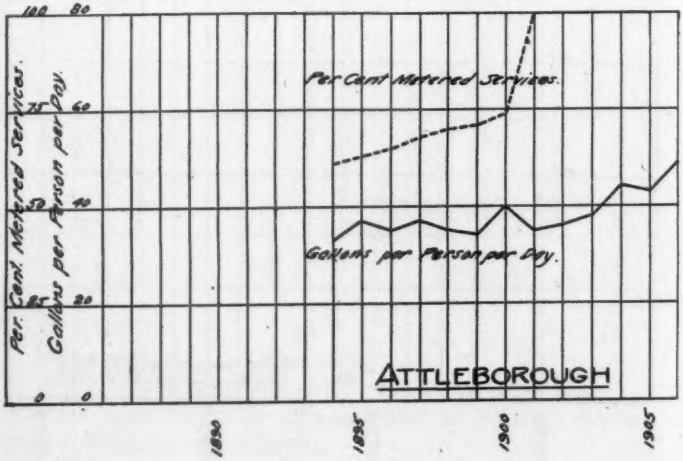

100
80
75
60
50
40
25
20
0
0
Per Cent. Metered Services.
Gallons per Person per Day.
Per Cent Metered Services.
Gallons per Person per Day.
ATTLEBOROUGH
1890
1895
1900
1905

FIG. 10.

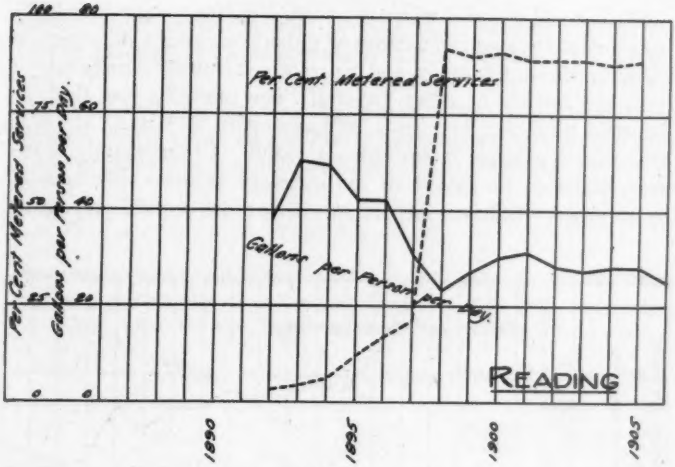

Per Cent. Metered Services
Gallons per Person per Day.
Per Cent. Metered Services
Gallons per Person per Day
READING
100
80
75
60
50
40
25
20
0
0
1890
1895
1900
1905

FIG. 11.

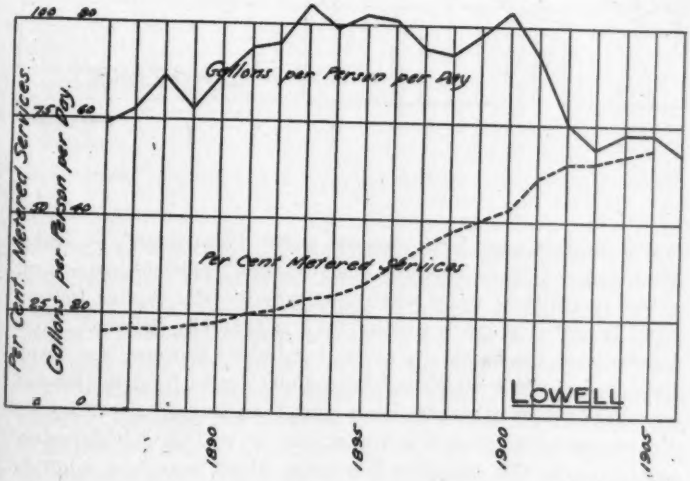

Gallons per Person per Day
Per Cent Metered Services
LOWELL
Per Cent. Metered Services.
Gallons per Person per Day.
100
80
75
60
50
40
25
20
0
0
1890
1895
1900
1905

FIG. 12.

The use and waste of water in houses includes water which leaks from defective pipes and fixtures or which is wasted by allowing the water to run continuously, and water which is intentionally drawn from the faucets or other fixtures. The quantity lost through defective plumbing fixtures is, in many cases, very large, and it is here that the house meter is most useful. Unfortunately, however, statistics in regard to the quantity actually lost cannot be obtained. Efficient inspection will do much toward preventing

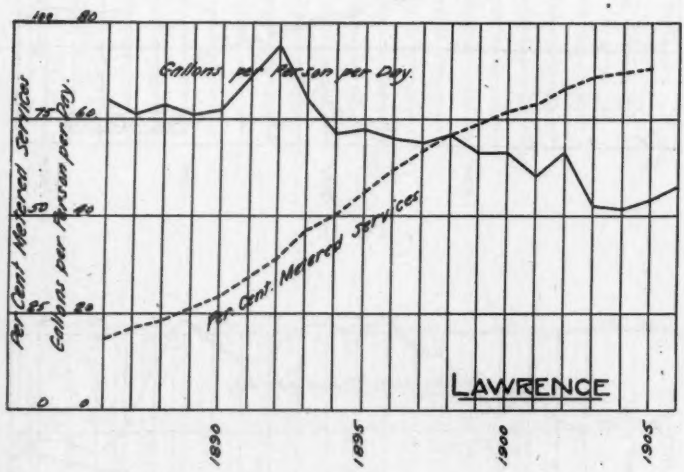


FIG. 13.

waste in this way, but increased water bills caused by leaky plumbing are more effective than the most efficient inspection.

The quantity of water wasted by intentionally leaving faucets open is probably much smaller than is generally believed. The line between the legitimate use and the waste of water is not well defined, but water which is intentionally drawn from the faucets or other fixtures, whether or not more than actually necessary for the purposes for which it is drawn, may be said to be legitimately used. Under this definition the water which is used by allowing the faucets to run during cold nights to prevent freezing may be

classed under legitimate use. Investigations have shown that the actual quantity of water consumed in this way is comparatively small.

The following table gives the relation which the consumption in each month bears to the average consumption, together with the average rainfall and temperature in Massachusetts:

TABLE No. 6.

PERCENTAGE WHICH THE CONSUMPTION DURING EACH MONTH IS OF THE AVERAGE MONTHLY CONSUMPTION, TOGETHER WITH THE AVERAGE RAINFALL AND TEMPERATURE. (MASSACHUSETTS.)

Average of Ten Years from 1896 to 1905.

Month.	Per Cent. of Average Consumption.	Rainfall. (Inches.)	Temperature. (Degrees F.)
January	90	3.68	23.9
February	92	3.98	24.3
March	89	4.77	34.9
April	87	3.86	45.6
May	100	3.18	57.2
June	113	3.60	64.5
July	124	3.85	70.7
August	118	3.97	67.6
September	108	4.12	61.4
October	96	3.35	50.9
November	90	3.34	38.7
December	92	3.74	27.7

It will be seen that the difference between the consumption during the coldest months and the consumption during April, — the month of minimum consumption, — is only 5 per cent. This excess of consumption generally comes in a few days, but it comes at a time when the sources of supply are least affected by a great draft upon them, except in cases where water is drawn from large storage reservoirs, and it comes at a time when the consumption is naturally small, so that the plant will not be called upon to do an excessive amount of work, as compared with the work required during the summer months. The cost of supplying the extra

water required to keep the faucets from freezing is insignificant as compared with the cost of repairing frozen pipes, and while I would not advocate putting plumbing in a house in such a manner that it would be necessary to allow the water to run during cold weather, I cannot criticise very severely the householder who uses a few cents worth of water to save a plumber's bill of many dollars, and if the water is sold at meter rates such use of the water is certainly legitimate. The quantity of water used for this purpose is undoubtedly greater than is necessary, and is reduced by the introduction of meters, but the total saving is in most cases an exceedingly small proportion of the yearly consumption.

The quantity of water actually used for strictly domestic purposes is increasing at a very rapid rate. In the first place, the number of fixtures in houses is increasing. This is especially noticeable in the less expensive houses, which now contain many plumbing fixtures where formerly a single faucet was all that would be provided. Not only is the number of fixtures increasing rapidly, but the quantity of water used by each fixture is increasing. The modern sinks, water-closets, and bath-tubs require very large quantities of water. The faucets and pipes are made of such a size that they deliver water much more freely, which tends to increase the quantity used. In the State House at Boston the water-closets are so constructed that every time a closet is flushed 5 gallons of water enter the sewer. The wash-basins are of such a shape and size that in order to obtain a sufficient depth of water for washing the hands it is necessary to draw from 1½ to 2 gallons, and the basins hold 2½ gallons when full to the overflow. It is easy to figure that a person of ordinary cleanliness, with such plumbing fixtures as those in the State House, and with a modern large-sized bath-tub, will use a much larger quantity of water than that allowed the average person in many of the estimates which are made of the quantity of water necessary for a water supply. The American people are undoubtedly wasteful, not only of water, but of all other commodities, and it is safe to say that they will not submit to being restricted in the use of water for which they are willing to pay any more than in the use of food supply or of fuel, of which large quantities are wasted.

Many interesting facts have been published from time to time

in regard to the actual consumption of water in houses of different classes, as indicated by meter readings. Table No. 7 gives a summary of recent studies made in Fall River, — a manufacturing city where the consumption is 42 gallons per person per day, — and in Needham,— a residential town where the consumption is 79 gallons per day. Meters are very generally used in both places.

TABLE No. 7.

STATISTICS IN REGARD TO THE CONSUMPTION OF WATER IN HOUSES OF DIFFERENT CLASSES IN FALL RIVER AND NEEDHAM, MASS.

(FALL RIVER.)

Class.	Number of Persons.	Gallons per Person per Day.	Persons per Water-Closet.	Persons per Bath-Tub.
A	44	49.6	1.6	2.6
B	160	23.7	2.5	4.3
C	550	13.2	3.9	8.3
D	792	12.2	7.6	*

(NEEDHAM.)

A	68	71	3	3
B	73	20	5	5
C	131	9	9	10

* No bath-tubs.

In each case class A represents the most expensive houses, surrounded by lawns, and the last class includes some of the cheapest tenement houses. When it is considered that a large proportion of the houses in Fall River would be included in the last classes, while a comparatively small proportion is included in the last class in Needham, a portion of the difference in the consumption of water in these two places is accounted for.

To further illustrate the difference in the consumption of water in different classes of cities or towns, Table No. 8, which gives the average consumption of water in the cities and towns of Massachusetts, arranged in groups, is introduced.

TABLE No. 8.

AVERAGE CONSUMPTION OF WATER DURING EACH MONTH IN 1905 IN CITIES AND TOWNS ARRANGED IN GROUPS.

(Gallons per Person per Day.)

Month.	Boston.	Metropolitan District.	Average of 23 Suburban Cities and Towns.	Average of 14 Large Manufacturing Cities.	Average of 37 Small Cities and Towns.	Average of 12 Summer Resorts.
January ..	165	137	77	70	48	67
February .	175	147	85	74	53	75
March	152	127	77	69	50	65
April	140	117	73	65	46	65
May	144	121	79	68	52	89
June	146	123	79	70	53	109
July	151	131	88	72	58	150
August ...	148	127	79	69	56	131
September	147	126	75	65	50	101
October...	145	124	73	65	47	74
November.	144	122	70	64	46	61
December .	153	129	71	64	45	65
Year	151	128	77	68	50	88

This table shows not only the difference in the average consumption for the year in the different classes of cities and towns, but it shows the monthly differences in the use of water. In the case of the summer resorts, the summer consumption is large for obvious reasons. In the suburban places there is a great quantity of water used on lawns and gardens, which increases the summer consumption.

These tables serve to show that there are natural differences in the use of water which cannot be overcome by the introduction of meters, and that it is impossible to produce, in places like Needham, conditions like those in Fall River.

The quantity of water used in manufacturing differs greatly in different places, due to differences in the character and location of the town, the character of the factories, and the attitude which the town takes in regard to supplying water to the factories. The quantity used in factories for sinks and water-closets has been determined from a study of the meter readings in a large number

of factories in various cities, and is found to be fairly uniform in places where water used for this purpose is metered. Table No. 9 gives characteristic results from several factories examined.

TABLE No. 9.

WATER USED FOR SINKS AND WATER-CLOSETS IN FACTORIES WHERE ALL WATER IS METERED.

Number of Operatives.	Water Used. Gallons per Day per Operative.
600	2.3
2 093	5.9
100	3.6
1 500	3.1
270	6.1
50	3.2
275	5.4
400	2.3
220	5.9
120	2.1
1 000	5.6
545	2.9
769	2.2
609	3.6
50	6.1
150	4.3
525	6.6
510	3.0
130	4.0
125	2.3
Average,	4.0

The figures in the above table are for factories where the water used is paid for by measurement. The quantity used in many factories where the water is not measured is very much in excess of these amounts, as the water is often allowed to run continuously through both sinks and water-closets.

The quantity of water used in manufacturing processes or for mechanical purposes is frequently large in comparison with the quantity used for strictly domestic purposes, and in some places the use of water by factories is encouraged by making only nominal charges for it, the smaller consumers being in such cases taxed for the support of the factories. There is now being constructed

for a New England city an expensive plant for the purification of 300 gallons per person per day, a large proportion of this water going to the numerous factories located in the city, but the city officials in this case prefer to incur the expense of a large purification plant rather than curtail the use of water in the factories.

In some cases factories are so situated that an independent water supply cannot be obtained, and it is necessary to obtain water from the public works. The quantity used in manufacturing processes can be ascertained only by investigation in each particular case, and before attempting to prophesy what can be done by domestic meters in any town, it is necessary to know how much water is used by factories and for mechanical purposes.

Table No. 10 contains interesting statistics in regard to the largest metered consumers of water in various cities and towns.

TABLE No. 10.

USE OF WATER BY LARGEST CONSUMERS.

City or Town. (Massachusetts.)	Average Daily Consumption.		Quantity Used by Ten Largest Consumers.		
	Gallons per Day.	Gallons per Person per Day.	Gallons per Day.	Gallons per Person per Day.	Per Cent. of Total Consumption.
Andover	484 000	73	61 800	9	12.8
Attleboro	641 000	49	62 100	5	9.7
Brockton	1 993 000	40	166 100	3	8.3
Clinton	543 000	42	146 100	11	26.9
Fall River ...	4 478 000	42	444 300	4	9.9
Lawrence	3 308 000	46	335 800	5	10.2
Lowell	5 084 000	54	189 900	2	3.7
Malden	2 000 000	51	113 100	3	5.7
Marlboro	554 000	39	98 600	7	17.8
Middleboro	263 000	38	77 000	11	29.0
Newton	2 223 000	59	115 100	3	5.2
North Andover	202 000	43	27 400	6	13.6
North Attleboro	282 000	35	15 000	2	5.3
Norwood	403 000	58	108 600*	16*	26.9*
Reading	147 000	25	7 300	1	5.0
Taunton	1 915 000	62	388 900	13	20.3
Watertown ...	771 000	67	134 700	12	17.5
Wellesley	273 000	43	24 300	4	8.9
Worcester	9 193 000	71	1 511 700	12	16.4

* Eight largest consumers.

The quantity used by ten of the largest consumers of water is given, together with the increase in the average per capita consumption due to these ten consumers. Upon studying this table some of the inequalities in the figures in consumption are explained. If the amount consumed by the ten largest consumers is deducted from the total consumption, the amount used by the remaining consumers in the different cities and towns is much more uniform. If 20 consumers had been included there would be a still greater similarity in the quantity used by the remaining consumers. It will be seen that in those places which have been so frequently referred to, namely Brockton and Fall River, there are no very large consumers of water. In Brockton the shoe shops use but little water, and in Fall River the water used by the factories is obtained from independent sources. In places having a large per capita consumption of water, the amount used by the large consumers is a very substantial proportion of the total consumption. In all of the places included in the table water is paid for at meter rates, and it is evident that the further introduction of meters in places like Norwood, Taunton, and Watertown is not likely to reduce the consumption to that of North Attleboro and Reading.

Very little is known about the quantity of water used for public purposes. Even where practically all of the domestic services are metered, it is not common to measure the quantity of water used for street watering, supplying drinking fountains, and other similar purposes. The quantity used for such purposes is undoubtedly very large, and in many places unnecessarily large, but in general the quantity so used will not be affected by the general use of meters. Statistics obtained from several places in Massachusetts indicate that the quantity used for such purposes amounts to from 4 to 10 gallons per person per day.

The quantity of water lost by leakage from street mains, distributing reservoirs, service pipes, etc., is in many cases very excessive. The best estimate of this quantity is obtained from a comparison of the quantity of water drawn from the sources of supply with the quantity of water passed through meters in those places where practically all of the services are supplied with meters. Statistics for a number of places where records of this kind are available are given in Table No. 11.

TABLE No. 11.

TABLE SHOWING THE RELATION BETWEEN THE QUANTITY OF WATER PASSED THROUGH METERS AND THE TOTAL QUANTITY OF WATER PUMPED IN 1905 IN CERTAIN CITIES AND TOWNS IN WHICH THE SERVICES ARE LARGELY PROVIDED WITH METERS.

City or Town (in Massachusetts when not otherwise indicated).	Per Cent. of Metered Services.	Total Quantity of Water Pumped in 1905. (Gallons.)	Quantity Passed through Meters. (Gallons.)	Per Cent. Passed through Meters.
Attleboro	100	200 753 000	94 728 000	47
North Attleboro	100	150 473 000	51 948 000	45
Wellesley	100	105 503 000	55 014 000	52
Ware	100	128 539 000	84 121 000	65
Yonkers, N. Y.	99	2 334 459 000	1 100 884 000	47
Fall River	97	1 608 652 000	956 168 000	59
Winchendon	97	35 446 000	16 154 000	45
Madison, Wis.	97	537 187 000	165 951 000	31
Needham	95	103 487 000	26 012 000	25
Worcester	95	3 517 397 000	1 881 254 000	53
Watertown	94	287 605 000	153 676 000	53
Brockton	90	732 083 000	416 188 000	57
Lawrence	88	1 094 881 000	570 736 000	52
Clinton	86	197 938 000	104 277 000	53
Newton	86	785 222 000	510 000 000	65
Burlington, Vt.	79	385 443 000	208 139 000	54
Andover	78	164 151 000	54 423 000	33
Malden	78	737 127 000	289 262 000	39
North Andover	74	72 170 000	23 557 000	33
Lowell	69	1 998 929 000	801 401 000	40
Cleveland, Ohio	68	22 053 442 000	10 780 154 000	49

It will be seen from this table that practically half of the water which is drawn from the sources is unaccounted for by the meters. This discrepancy is doubtless due in part to errors in the registration of the meters and in part to errors in the rating of the pumps where the quantity drawn from the sources is determined by the pumping records. There is also, in many of these places, a large quantity of water which is used for street sprinkling and for drinking fountains and similar public uses which is not measured, but after allowance has been made for all of these errors and uses there still remains a large quantity of water which is not accounted for which must be attributed to leakage in the system. To whatever this discrepancy between the quantity drawn from the sources

and the quantity actually used is due, — whether to the use of the water in the streets or to leakage, — it is evident that it is not affected by the use of meters. The quantity thus unaccounted for in the places included in the table amounts to a per capita consumption of from 14 to 70 gallons per day.

In practically all of the places included in the foregoing tables the water supply is obtained by pumping, as it is, unfortunately, only in such places, as a rule, that any knowledge can be obtained as to the quantity of water used. In only a few cases where water is supplied by gravity are there any means of measuring the water, and it is safe to say that the consumption, in places where nothing is known of the quantity of water consumed, is much greater than in those places where such records are kept. It is undoubtedly a fact that in some cases almost as much would be accomplished by the introduction of large meters on the main lines of supply as by the introduction of house meters. In this connection I can do no better than to quote from a statement made in 1900 by Mr. X. H. Goodnough, chief engineer of the Massachusetts State Board of Health:

"In cases where water is supplied by gravity it is generally considered unnecessary and often a waste of money to attempt to make any continuous and approximately correct record of the quantity of water used. There is no doubt, however, that in many such cases a knowledge of the excessive use of water would lead to a great reduction in waste and to a saving in the cost of construction and operation of the works far greater than the expense of making the necessary measurements."

A good illustration of the value of a knowledge of the quantity of water used is found in the experience of the city of Holyoke, where meters were recently introduced on the main lines of supply. It was found upon reading these meters that the average daily consumption of water in the city was 144 gallons per person. Upon making this discovery steps were immediately taken to ascertain where the water was going, and by vigilant inspection during a period of a few months the consumption was reduced to 103 gallons per day, the actual saving of water amounting to over 2 000 000 gallons per day. During the investigations which were made it was found that large quantities of water were being

stolen, and it is said that the revenue has been increased very materially by these discoveries, directly attributable to the introduction of large meters on the supply lines.

From a consideration of the foregoing facts it is evident that disappointment is inevitable in the case of many cities and towns where meters are being introduced. In the case of one town which has recently come to my notice, the population is about 10 000 and the per capita consumption is from 96 gallons per day in winter to 128 gallons per day in summer, and the general introduction of meters has been recommended to obviate the necessity of obtaining an additional supply. In this town one factory uses 200 000 gallons of water per day, — amounting to 20 gallons per person per day, — the water being furnished under a fifty-year contract, the town to receive one-half cent per thousand gallons. There are other factories in the town which are supplied with unknown but probably smaller amounts of water. The town uses cement-lined, wrought-iron mains, which are laid in a sandy soil where leaks of considerable size would remain undetected for a long time. There is also a very large summer population, which increases the draft during the summer months. While the general introduction of meters in this town would undoubtedly result in a saving of water, and should be unhesitatingly recommended, it is certain that results like those obtained in the cities of Brockton, Fall River, and Providence are not possible, and it is doubtful if the consumption in this particular town can be reduced to less than from 80 to 90 gallons per person per day, without restricting the use of water in the factories.

I do not wish to be understood to question in the least the advantages of selling water by measurement. I am convinced that it is the only proper method of selling water, and that it should become universal. Neither do I question that a great saving in the use of water can be made by the introduction of meters. The most recent experience, however, shows conclusively that the extravagant claims which have been made as to the reduction in the quantity of water made possible by the introduction of meters are not fulfilled, and I have endeavored to show by an analysis of the figures some of the reasons why the predicted results have not been accomplished, and why they are not likely

to be accomplished with the present tendency toward a greater use of water for almost every purpose. I have also endeavored to show that a prediction as to what meters will accomplish in any particular case should not be made without some knowledge of the principal sources of use and waste, to determine how much of the consumption is susceptible of regulation by meters.

DISCUSSION.

PRESIDENT JOHN C. WHITNEY. Gentlemen, the paper is now open for discussion. There is an opportunity for the gentlemen representing the communities referred to by Mr. Johnson to explain why it is that meters have not restricted the consumption of water in certain places.

MR. GEORGE A. KING.* Mr. President, there is one point which, it seems to me, bears on this question that Mr. Johnson has not touched upon, and that is the care of the meters. I noticed that in a great many of the cases quoted the consumption decreases for five or six years, and that it then begins to increase. With the little experience that I have had, I have noticed that after four or five years the meters do not do their duty, and they should be taken out, cleaned, and repaired, and that then they will register as they should. If an increased consumption is not followed by an increased bill, the consumption will further increase. The increased consumption may not be shown by the meter because it is more or less out of order. I think that this may account for some of the increases in consumption based on the pump records. I have one case in mind where I took out a meter on which there were four tenements. Those four tenements had not been consuming 40 000 gallons a year, according to the meter. For the first year, or a little over ten months, I think, after the meter was changed, the bill increased from $10 to $25, and last year the bill was over $30. I think that the lack of care of meters may account for some of the difference which Mr. Johnson shows.

THE PRESIDENT. I wonder if Mr. Johnson has taken into account, in making up his figures, the date of the introduction of sewers into these various towns?

MR. JOHNSON. I gathered together some figures to show the

* Superintendent of Water Works, Taunton, Mass.

effect of the introduction of sewers on the consumption of water, but the information was so meager that I did not care to present it. I found that the average consumption for the year previous to the introduction of sewers in six cities and towns was 42 gallons per person per day. In the same cities the year after the completion of the sewerage system the consumption was 48 gallons per person per day. The increase in the consumption in seven years previous to the construction of the system was 9 gallons per person per day, and in the six years after the completion of the system the increase was 13 gallons per person per day.

MR. CHARLES W. SHERMAN.* There is one other point which Mr. Johnson has not touched on, and which might in the case of some of the smaller cities and towns have some effect on the figures of per capita use of water, where the figures presented are based on total population, and that is a gradual extension of the water system to include a larger portion of the town. In the case of small towns especially there are often outlying districts of considerable extent which are not reached by the water system, and if the total population of the town is taken in figuring the consumption, the result would naturally be materially different from the consumption per person actually supplied. As the works gradually extend to the outlying districts the per capita consumption would tend to a larger figure, even though the actual consumption or use of water per consumer remained unchanged. That consideration should be borne in mind in considering the smaller places; probably in the larger it would have no appreciable effect. Referring to the question of water unaccounted for, I am somewhat familiar with the records of a small water company in Iowa, where the policy of metering every service was adopted about three years ago. The main pipe system was constructed ten or eleven years ago, and it has not, of course, been possible to overhaul that. The best estimates possible of the amount of water used for street watering and for any other unmetered use of water, as at fires, — which represent comparatively small quantities, as the town is not a large one, — are made, and a reasonable allowance made for slip of the pumps; and upon that basis the quarterly records of the water pumped, as compared

* Civil Engineer, Boston, Mass.

with the quarterly meter readings, shows the amount unaccounted for to be about 33 per cent. of the total water pumped. The mains have been carefully examined so far as possible, and the whole system has been examined for leaks back of the meters. Some were discovered in the first examination, but not enough to make an appreciable effect on the percentage unaccounted for. In making the investigation, we found what perhaps many of the members may not be familiar with, — a little instrument known as the phonendoscope, once used by physicians, which is practically a type of stethoscope, in which the diaphragm has a little metallic or hard rubber rod extending from it. This can be put against a gate valve in listening for leaks, and the ear tubes, as in the ordinary stethoscope, concentrate the sounds very nicely. The whole instrument is contained in a little nickeled box about 3 inches in diameter and an inch and a half thick. It is a very valuable instrument for such purposes.

Mr. Walter H. Richards.* Mr. President, in this connection I should like to refer to an incident that has just come to my notice. A superintendent of water works in a small town referred to me to see if I could help him out of this difficulty: He had a new meter on some buildings which had been in use about a year, and he was not satisfied with the registration, so he put on a second meter, on the same line of pipe, and after taking the registration for a month or two, he found that it registered 39 per cent. less than the first meter. That did not satisfy him, so he put on another meter, and after running a month or two, that registered about 35 per cent. more than the second meter and 9 per cent. less than the first one. As he had no meter tester, he sent them on to me to test. I tested them and found them all practically correct, every meter, from my testing. There was considerable sediment, iron rust, came out of the meters when we blew them off, as we have to do before testing them.

Regarding the showing of the tables presented to-day, while they show an apparently increased consumption per capita with the introduction of meters, this increase is not necessarily waste, and as a matter of fact the waste may be, and probably is, reduced, the increase being due rather to the increased use of water-closets,

* Superintendent of Water Works, New London, Conn.

baths, or other sanitary fixtures made possible by an extension of the sewer system; and even the establishment of a large factory might increase the per capita consumption. That the per capita consumption increases and is increasing for local special reasons is undoubtedly true, and that the introduction of meters decreases the waste is equally true and proven.

The tables illustrate the fallacy of drawing conclusions from statistics when some of the factors are omitted.

MR. JOHN F. J. MULHALL.* Mr. President, there was one question overlooked in Mr. Johnson's paper; that is, in reference to slip of pumps. In Mr. Wheeler's companies, — he and his associates operate about twelve, — we keep daily records of the pumpage, and make an average per year of the annual consumption in Massachusetts. The average per capita per year seemed to us so enormous that we made an investigation and found that the pumps showed a slip of between 20 and 30 per cent.,— between 40 and 50 per cent. on one pump. I understand that Mr. Johnson has given figures computed on the displacement of the pumps, and that would account, in some cases, — in fact, I think in the great majority of cases, — for the great percentage of unaccounted for water, in addition to the leaks in the system.

MR. DEXTER BRACKETT.† Mr. Johnson's paper is a very valuable contribution to the literature on this most important subject, and I am pleased to note that he believes that the only proper method of selling water is by measurement. It must not be expected, however, that the measurement of water supplied to individual water takers will prevent leakage and waste from the street mains. What is required in order to obtain the best results is a complete system of measurement of all the water used, not only that used and wasted by the individual water takers, but also that wasted from street mains as well. If, with a system having 95 per cent. of the services metered, only 25 per cent. of the quantity supplied is accounted for by the meters, it can safely be assumed that there is a large leakage from the street mains, which should be prevented. By supplying sections of a distributing system through large meters, leaks from the distributing

* Water Works Accountant, Boston, Mass.
† Chief Engineer Metropolitan Water Works, Boston, Mass.

pipes can often be located, and the stopping of a few of these leaks often results in the saving of a large amount of water.

I think the writer has underestimated the quantity of water which is wasted from faucets intentionally left open, and I cannot agree with the opinion that all water which is intentionally drawn from water fixtures may be considered as legitimately used, including water allowed to run to prevent freezing of services. As an illustration of the quantity used for this purpose, the following examples taken from records of the Metropolitan works may be mentioned. The average per capita consumption in the city of Chelsea during the months of December, January, February, and March for the past three years has been respectively 55, 52, and 41 gallons greater than the average for the months of November and April. As the only cause for increased use during the winter months is the waste to prevent freezing of services, it follows that the average family of five persons in the city of Chelsea uses yearly about 30 000 gallons of water for this purpose, which, at the usual meter rate of 30 cents per 1 000 gallons, has a value of $9. The actual quantity used by those who follow this practice is much greater because not all the water takers find it necessary.

The city of Boston used about 30 gallons more per capita during the months of December, January, February, and March than during the months of November and April, indicating a use or waste of 10 gallons per inhabitant, or 6 000 000 gallons per day *for the whole year*, for preventing the freezing of services, — a quantity which can hardly be considered insignificant.

Doubtless a few water takers will use some water for this purpose even if supplied by meter, but in places where meters are in general use the increase in the quantity used during cold weather is comparatively small. In Belmont, Malden, Milton, and Watertown, where practically all the services are metered, the per capita consumption during the winter months of 1906 and 1907, as compared with that of the months of November, 1906, and April, 1907, was as follows:

	Average Nov. and April (Gallons).	Average Four Winter Months (Gallons).
Belmont	54.5	57
Malden	47.5	49
Milton	42.0	41
Watertown	66.0	60

It cannot be expected that the per capita consumption in cities which have a large transient population, or where there is a large use of water for business and manufacturing purposes, can be reduced by the use of meters to 50 gallons, and in some cases probably not below 150 or 200 gallons; but the experience of the cities and towns of New England where water is paid for in proportion to the quantity used proves that in places having a population of less than 50 000 the average per capita consumption should not exceed 50 gallons unless the manufacturing use is disproportionately large. On the other hand, in a city like Buffalo, N. Y., where the cost of water is small, and where the 2 per cent. of the water takers who are supplied through meters use a quantity equivalent to 46 gallons for each inhabitant of the city, the universal use of meters would probably not reduce the per capita consumption below 150 or 200 gallons.

During the past twenty years there has been a great increase in the number of water fixtures per capita, an increase in the quantity of water required per fixture, and a tendency toward an increase in the pressure furnished, all of which tend toward an increase in the use of water. So long as the water is paid for at schedule (fixture) rates the water taker has little interest in the quantity used, but with the general use of meters more attention will probably be given to the determination of the number and size of fixtures required to give the best results, as in the case of lighting at the present time, where attention is now given to the question of obtaining the burners which give the best results with the least expenditure of gas and electricity.

The quantity of water used in the eighteen municipalities supplied by the Metropolitan works is now measured by Venturi meters, and figures showing the per capita use of water in these municipalities may be of interest in the study of this subject. Table No. 12 gives the per capita consumption, as well as the population and percentage of services metered in the different cities and towns supplied by the Metropolitan works for the year 1906:

TABLE No. 12.

POPULATION, PERCENTAGE OF SERVICES METERED, AND CONSUMPTION OF WATER IN THE MUNICIPALITIES OF THE MASSACHUSETTS METROPOLITAN WATER DISTRICT. 1906.

City or Town.	Population. 1906.	Per Cent. of Services Metered.	PER CAPITA CONSUMPTION. (Gallons.)												
			January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Av. for Year.
Boston	601 430	5	158	162	154	146	149	151	148	149	149	143	141	165	151
Somerville	70 950	19	88	88	83	81	90	93	92	94	92	89	84	92	89
Malden	39 040	78	51	50	49	50	52	54	55	53	54	48	48	49	51
Chelsea	38 000	10	102	117	106	92	89	92	93	97	97	87	83	113	97
Everett	30 270	2	83	91	84	78	80	83	80	82	80	74	69	87	81
Quincy	28 300	3	105	107	108	103	112	117	109	113	115	99	95	97	107
Medford	20 080	8	91	94	90	90	104	105	103	108	117	104	96	101	100
Melrose	14 650	3	112	111	109	111	113	106	108	110	113	107	101	106	109
Revere	13 390	4	67	74	73	66	80	97	99	104	93	73	68	85	82
Watertown	11 550	93	60	59	60	64	73	74	70	69	71	71	69	61	67
Arlington	9 940	22	70	75	72	72	88	90	83	87	94	82	76	76	81
Milton	7 120	100	36	35	39	42	62	64	56	61	61	47	43	44	49
Winthrop	7 240	2	98	104	98	96	106	127	135	145	131	107	98	110	113
Stoneham	6 350	2	62	63	59	62	67	69	69	76	84	78	72	71	69
Belmont	4 410	100	38	38	45	54	76	77	71	76	92	65	52	56	62
Lexington	4 230	2	57	60	62	74	97	101	96	98	92	79	68	66	79
Nahant	1 850	18	62	68	62	68	69	74	68	80	82	48	74	85	71
Swampscott	6 240	0	87	75	68	71	74	78	87	96	88	68	76	66	79
Metrop'lit'n Distr't,	915 040	12	132	136	129	123	128	130	127	129	129	122	119	138	128

MR. ROBERT J. THOMAS.* Mr. President, I noticed in Mr. Johnson's paper that Lowell was an exception to the rule, and doesn't quite coincide with his conclusion as to the increased consumption of water after meters were placed. According to his diagram and the figures for 1906 in my possession, the consumption of water in Lowell for 1906 was the lowest it has been for seventeen years.

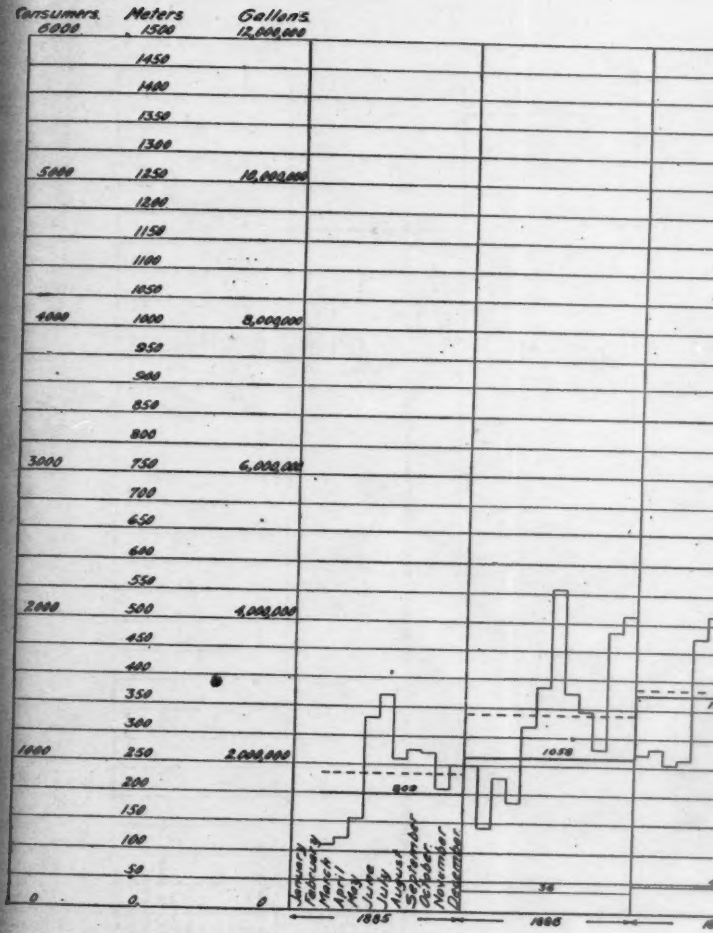
This decrease in consumption is due, unquestionably, to the use of meters. For a number of years the city of Lowell put on meters as the consumers of water applied for them, and those applying for meters generally were people who built good houses to live in themselves and were satisfied that they would save money by meters. In other words, the placing of meters was optional. Consequently that didn't affect the consumption of water greatly. But in 1900, several years after driven-well water was introduced, the water board applied meters to a thousand services where they believed, from the reports of their inspectors, that water was being wasted. The effect was almost immediate — within the year. A decrease of consumption took place, and ever since this compulsory placing of meters on all new services has carried that same result along with it. The reduction in the consumption of water began in 1900; and the consumption has been working down, so that last year, 1906, it was the lowest for seventeen years, due undoubtedly to the enforcement of the meter system and the placing of a thousand meters on the most wasteful services.

As to the matter of the improvement in the quality of the supply having anything to do with it, I doubt very much the effect of that, because, as I said, although the new water supply was introduced in 1896, — that is, the well systems were built then, — it was since then that this great decrease in the consumption took place.

Now, Mr. Johnson speaks of Yonkers and the great increase of the consumption of water there. I know for a fact that in Yonkers they improved the water supply recently. They put in driven wells and they filter their water, so that ought to decrease the consumption as it did in Lowell, instead of increasing it.

In regard to the assumption that letting water run in winter season to keep it from freezing is legitimate, I take issue with Mr. Johnson. I think a house where the water pipes will freeze is not a fit habitation for a human being.

* Superintendent of Water Works, Lowell, Mass.


Consumers.
Meters
Gallons.
6000
1500
12,000,000
1450
1400
1350
1300
5000
1250
10,000,000
1200
1150
1100
1050
4000
1000
8,000,000
950
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600
550
2000
500
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450
400
350
300
1000
250
2,000,000
200
150
100
50
0
0
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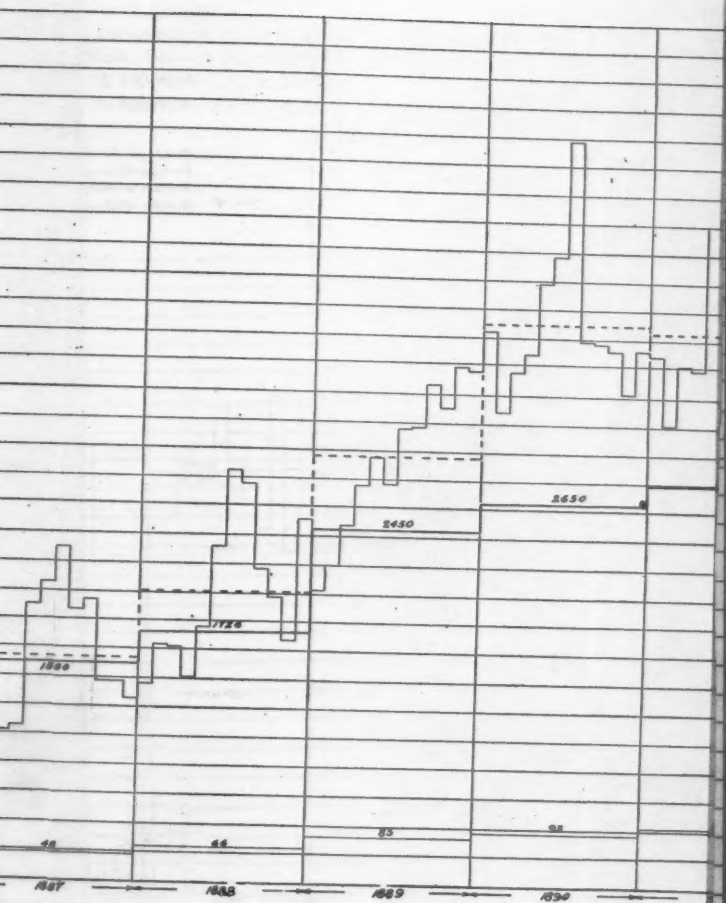
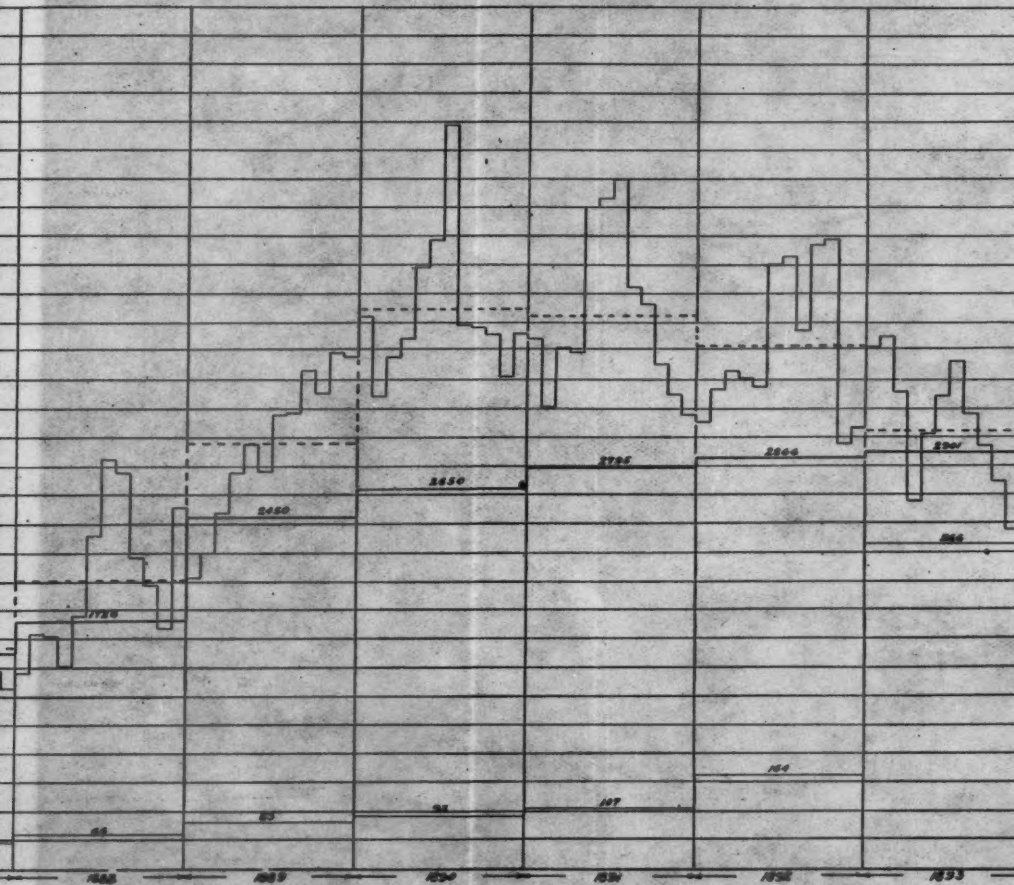
January
February
March
April
May
June
July
August
September
October
November
December
1885
1886
1058
809
36


1886
1726
2450
2650
1887
1888
1889
1890


2450
2785
2944
2901
2965
1728
164
107
92
85
65
1888
1889
1890
1891
1892
1893

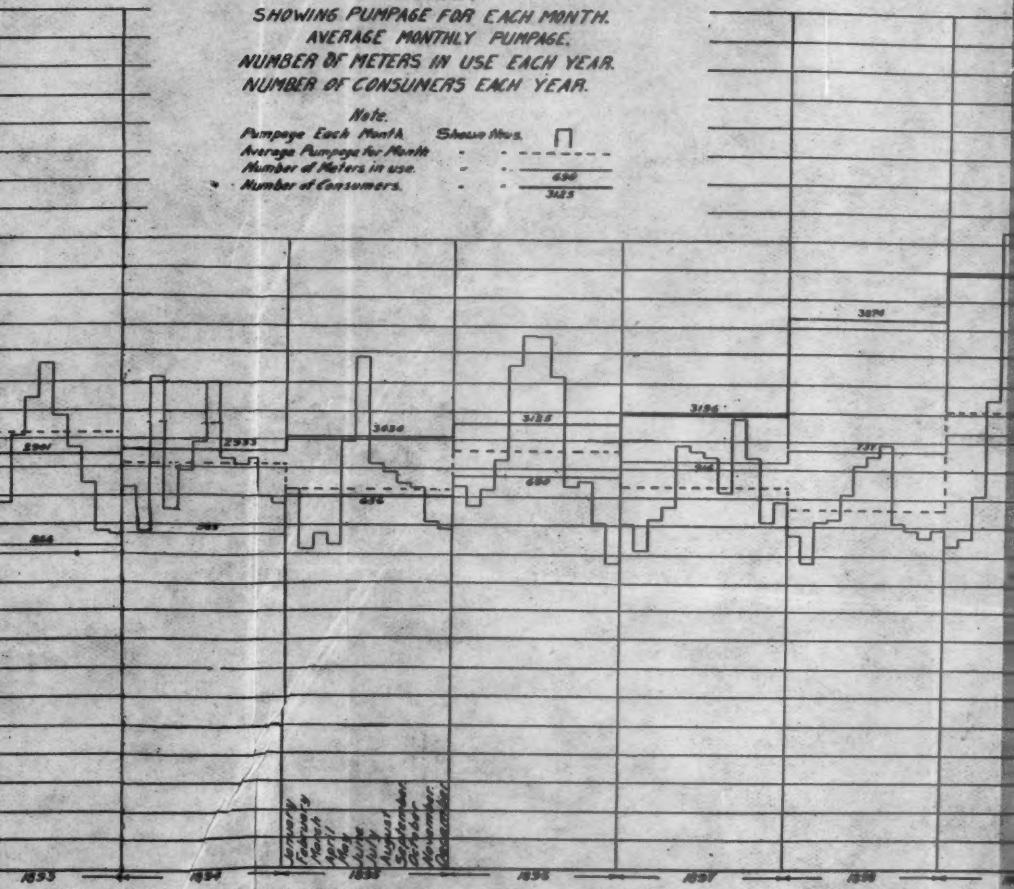
WELLESLEY WATER WORKS.

DIAGRAM

SHOWING PUMPAGE FOR EACH MONTH.
AVERAGE MONTHLY PUMPAGE.
NUMBER OF METERS IN USE EACH YEAR.
NUMBER OF CONSUMERS EACH YEAR.

Note.

Pumpage Each Month. Shows thus.
Average Pumpage for Month " "
Number of Meters in use. " " 650
Number of Consumers. " " 3425



LEY WATER WORKS.

DIAGRAM

F PUMPAGE FOR EACH MONTH.
RAGE MONTHLY PUMPAGE.
F METERS IN USE EACH YEAR.
F CONSUMERS EACH YEAR.

Note.
h Month. Shown thus.
ge for Month
ters in use. 600
sumers. 3125

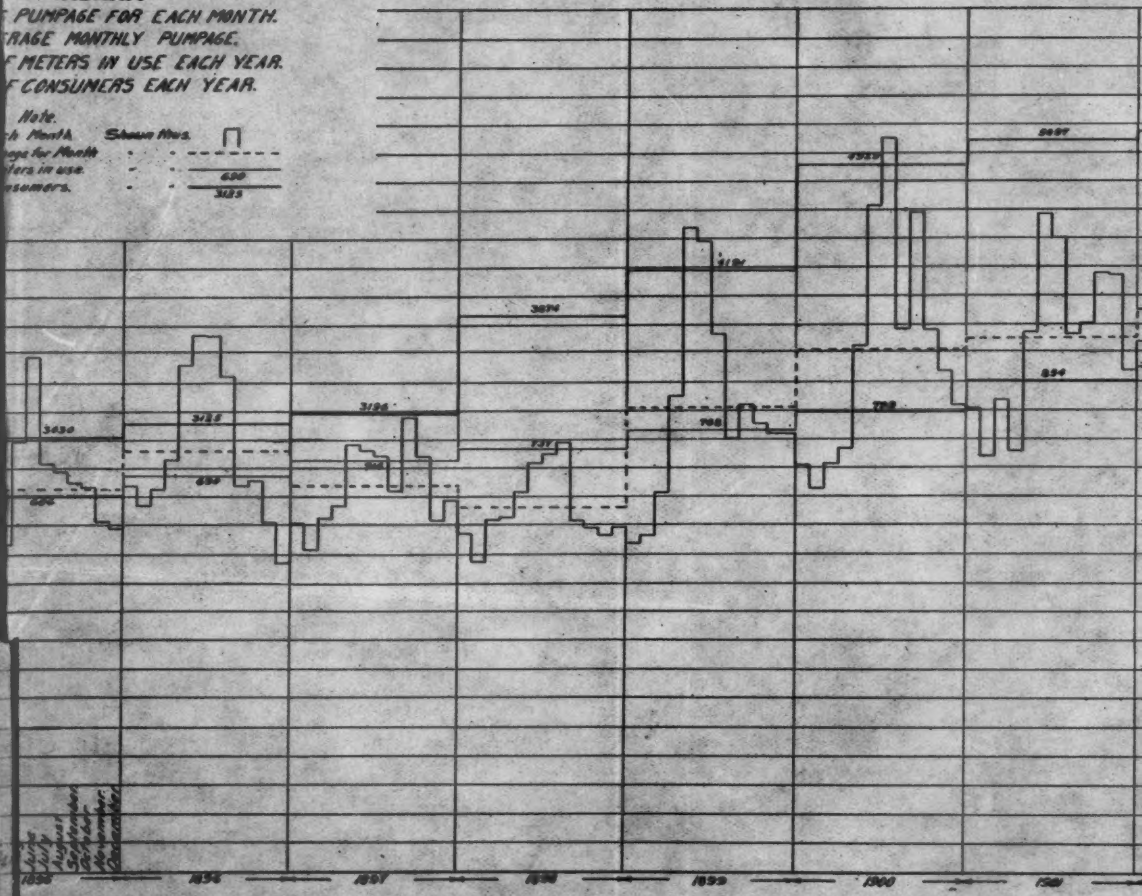
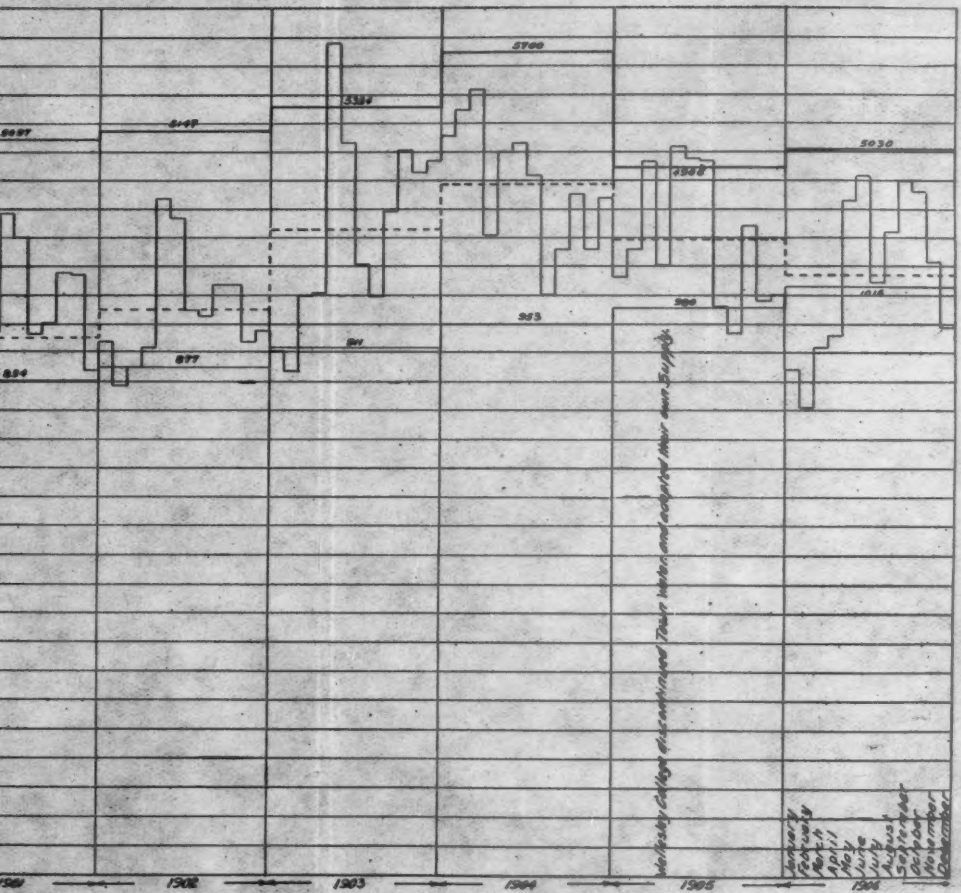


PLATE I.


5700
5384
5030
5147
5097
5028
953
909
1018
911
877
854
1902
1903
1904
1905
1906
January
February
March
April
May
June
July
August
September
October
November
December

The average daily consumption in Lowell last year was about 5 000 000 gallons, with a population of about 100 000 people. If we had not applied meters our consumption would be nearly three times as much, and if it were, we would have to use Merrimac River water to-day, because the quantity of well water would not be sufficient to supply such extravagant and excessive use of water. And that would mean a very serious proposition for the city of Lowell. In 1890 Lowell had over 496 cases of typhoid fever and 124 deaths when using Merrimac River water. Last year, using well water, there were 7 deaths from typhoid fever, with about 27 cases. That speaks for itself. That is an argument in favor of meters very convincing to me.

MR. FRANK L. FULLER.* Mr. President, I want to second what has been said in regard to the value of the paper which Mr. Johnson has presented to us. I know from experience in investigating such subjects that he must have put a large amount of work into it, and I think he deserves much credit for what he has done.

Just before coming to this meeting I received the proof of a diagram which has been prepared for the Wellesley water report for 1906 (Plate I). This diagram is instructive and throws light on the question of the introduction of meters.

The Wellesley works were built in 1884, and the use of water commenced the following year. Almost immediately the use of meters began in a small way. Their use was not compulsory, but water takers were allowed to install them, and a rate for metered water was established.

The amount of water pumped increased very rapidly. For instance, in 1886, with 1 058 consumers, the average pumpage was about 2 700 000 gallons per month, and this increased until, in the year 1890, with 2 650 consumers, the pumpage was a little less than eight million gallons per month.

At the close of the year 1892 there were 164 meters in use. The next year (1893) 402 meters were added, and at the close of that season 566 were in use. The number of service taps at the close of 1893 was 610, which indicates that meters had been placed on nearly all services.

The 402 meters mentioned above is the largest number of meters installed, or likely to be installed, in any one year.

* Civil Engineer, Boston, Mass., and member of Water Board, Wellesley, Mass.

As soon as nearly all consumers used water through meters, the pumpage of water began to decrease. By an examination of the diagram it will be seen that the amount of water pumped in 1890 was about the same as in 1902, or twelve years later, while the number of consumers had increased from 2 650 to 5 147, or had nearly doubled.

I do not know what the condition of the Wellesley water supply would have been at the present time if meters had not been introduced. Before meters began to be generally used, the pumpage practically doubled every second year. The town would have been compelled to go outside of its own limits to secure a new supply, or would have been driven to the expensive expedient of installing a plant for the filtration of the water of Rosemary Brook or Charles River. With all consumers metered, the town of Wellesley now has a sufficient supply for some years to come.

The following table is obtained by dividing the total pumpage for each year (obtained from the plunger displacement) by the number of consumers for that year. It, of course, includes water used for sprinkling streets and lawns and the small amount used in extinguishing fires and flushing pipes. It is somewhat too large on account of insufficient allowance for slip of the pump, which was corrected for the year 1906. The pumping engine is of the duplex pattern, made by the Geo. F. Blake Manufacturing Company in 1884, and has a capacity of 1 000 000 gallons in twenty-four hours.

Year.	Daily Supply of Water per Consumer. Gallons.	Year.	Daily Supply of Water per Consumer. Gallons.
1885	64	1896	62
1886	84	1897	55
1887	67	1898	43
1888	77	1899	51
1889	79	1900	48
1890	97	1901	48
1891	91	1902	50
1892	84	1903	55
1893	69	1904	55
1894	63	1905	59
1895	58	1906	54

I should like to emphasize what has been said in regard to the importance of knowing the exact amount of slip to be allowed

for when pump records are used in determining the amount of water pumped during the year. The Wellesley pump was tested last year and the slip found to be about 11 per cent. An allowance had previously been made, but probably not enough. All pumping engines should be tested for capacity as often as practicable,—at least once in two years,—if fairly accurate results are to be expected. It is probable that most pumps are not delivering the amount of water with which they are credited. In towns where the entire consumption is metered, a portion (it may be small) of the great discrepancy between the pump and meter records may be due to overrating the capacity of the pump.

Dividing the total amount of water passed through meters in Wellesley by the number of consumers, we have as the average daily amount of water *used* by each consumer, 33 gallons. The difference between this amount and the 54 gallons obtained from the pump record is 21 gallons per consumer, which is lost in various ways.

In order to locate this loss, our superintendent made a careful test of our 600 000-gallon covered reservoir (the one ordinarily used) for twenty-three hours and found it practically tight. We have in use one of Mr. Winslow's recording gages, and from the card which comes from the dial it appears that there is lost from the system during the twenty-four hours about 16 gallons per consumer. This is based on the loss from 12 o'clock midnight to 5 o'clock A.M. By taking this draft, when there should be little or no consumption, deducting the flow of three drinking fountains, and applying it to the entire twenty-four hours, an amount of 16 gallons, as mentioned above, is obtained.

Probably a very small part of this amount is legitimate use, but most of it is no doubt due to leakage from the pipe system, which is composed of 32.7 miles of cast-iron distribution pipe and 20 miles of wrought-iron cement-lined service pipe, a total of nearly 53 miles. In many houses there is more or less dripping from faucets due to defective washers or to the fact that they are not closed tightly. A little silt or a particle of solid material may lodge under a valve in a water-closet tank and allow the escape of a small amount of water. These leakages may often be too small to move the piston or disk of the meter, and thus be unrecorded.

As a matter of interest and information, I keep a record of the daily reading of the meter in my own house. During the last thirteen years the average daily consumption per person per year has varied from 12 to 24 gallons. This amount has been largely used within the house, but little being used for watering lawn or garden. The house for twelve of the years mentioned contained water-closet and bath-tub. Set tubs for washing were added last year and will, no doubt, act as a factor in increasing the amount of water used. There is no sewer system in Wellesley.

The facility with which water can be obtained and disposed of in a house has much to do with the amount used.

As previously mentioned, the average metered consumption in the town was 33 gallons per consumer. In my own family it has averaged for thirteen years 18 gallons per day per consumer. So far as indoor consumption has been concerned, only moderate care in the use of water has been exercised.

The use of meters in Wellesley has been entirely satisfactory and their use has saved the town many times their cost, in putting off the time when great expense will be required for a new or increased supply.

Our meters have been carefully attended to, and the cost last year for maintaining a little over 1 000 meters was $270, or less than 27 cents each.

There is probably no doubt, as Mr. Johnson has pointed out, that even with meters, owing to greater facilities in using and disposing of it, the consumption of water is increasing from year to year, but there is no question in my own mind that without meters the increase would be vastly greater. The results at Wellesley confirm this opinion.

Mr. George Cassell.* Mr. President, as Mr. Brackett has stated, Chelsea is one of the most wasteful cities in regard to water in the Metropolitan district, and in view of the fact that Mr. Johnson has made a statement to the effect that water meters do not accomplish the stoppage of waste (if this is true, I find myself in the position of advocating something that doesn't amount to anything), he has completely knocked my statements into a cocked hat.

* Superintendent of Water Works, Chelsea, Mass.

Now, I want to say a few words in relation to Chelsea and its consumption of water. Our city is supplied by gravity, is in the Metropolitan water district, and we are very cosmopolitan. We have a very condensed population, and a population of a character which should, perhaps, use more water than any other city; but we cannot all be Brookliners or Newtonians. [Laughter.]

Aside from the statement that the use of meters for stopping the waste does not accomplish the purpose, I believe that it is the only legitimate way in which to sell water to people who want to use it; especially in those cities that are in the Metropolitan district and where the water is purchased by measure. The old method of assessing by the fixtures, or otherwise, is antiquated and gone by. There is no justice in it; it is all guess work.

We started into the meter business because of the fact that we were attached, as I said before, to the Metropolitan water district, and the officials are not very slow in charging one for what he gets; and instead of coming down in price they keep going up. I don't know as I blame them any, because if the people are bound to waste the water they must pay the bill, and the only way to make them do so is by installing a meter and have them pay for what they use and waste.

In 1905 we had installed 951 meters. Previous to that our consumption was, I believe, 110 gallons per capita. In November of that same year we dropped to 82 gallons per capita, and of course I laid it to the use of meters, but I see that I was wrong. [Laughter.]

In December last we had a little cold snap and were informed by the state that the consumption had increased from two million and a half up to four million and a half per day, and that caused me to do a little thinking. I could only figure it out in one way, — that the increased consumption was due to the fact that the people were letting the water run to keep it from freezing. Now, I don't know in what sense Mr. Johnson used the word " legitimate " in connection with his view of it, but it didn't appeal to me, as the majority of those letting the water run were not occupying metered premises, and I have the practical side of it. Aside from that, however, in this steady cold snap that we have just had, the consumption increased until it got up to approximately

173 gallons per capita, or an increase from 3 000 000 gallons to 6 550 000 gallons daily, and that, according to Mr. Brackett's statement, was costing the people in my city approximately $150 a day.

Now the injustice of it comes right here. That was practically water which was wasted in consequence of the cold condition of the houses, the occupants of which let the water run to keep the pipes from freezing. As Mr. Thomas said, the houses were in such a condition that they had to let the water run to keep it from freezing. If that is legitimate use, and the people want to pay for it, all right, if the premises are metered and the state can supply the water.

Under the flat rate, the man who is not obliged to let the water run because his house is warm is the sufferer, as he is made to pay for what the other man wastes; but still they tell you it is an injustice to put a meter on his house to curtail that " legitimate," use of water by letting it run to keep it from freezing.

As I said before, we jumped from 82 gallons per capita in November to 173 gallons per capita during the cold period, which meant practically 91 gallons per capita waste; and if we could get along with 82 gallons per capita, including manufacturing and everything else, in November, why couldn't we do it every month? The question answers itself. It was simply because of the cold snap and the water being allowed to run until such times as tenants became satisfied that the weather was such that the water wouldn't freeze any more.

As previously stated, we have installed 951 meters. We collected with these during the year an excess of close to $10 000 over and above the minimum charge, which was $12 for the year. That was all very well in one sense, but it was hard on the water registrar in another, and as I happen to be the registrar in my city, I got the practical side of it everywhere. The fact remains, however, that if we are going to stop the waste of water we must educate the people up to the use of the meter, no matter what the result is, and I thoroughly believe that meters are the only legitimate means to stop the waste. You may talk about inspectors all you please. Why, there would have to be one stationed at every house!

One day I met a gentleman of Jewish extraction, a very nice man, and he said, " My God, Cassell, I paid $300 last quarter for water; what do you think of that?" " It is too bad," I replied; " how did it happen? " and he said, " The people in the houses let the water run to keep it from freezing." I said: " Those are nice houses that you have built down there and the plumbing looked all right; did you do anything to prevent the pipes from freezing? " He answered, "No." " Why didn't you pack the pipes? " I asked, and he replied, " What is the use? They will tear the boxing away and burn it up and everything that is around it." [Laughter.] I said to him, " Who is to blame? " " Oh," he answered, " the damned people who live in the houses. They are so damned ignorant you can't do anything with them. I put door strips on the doors to keep the cold out of the houses, and what do you think? They stole them all off." [Laughter.]

Now, that is exactly so. It is a hardship, we must all admit, upon the owners of houses who, no matter how patiently and conscientiously they try, cannot control the people who occupy them.

In our city we have a large but not very wealthy population, and a good many times I am surprised, when I get into an argument with gentlemen of my city, because they try to compare it with Brookline. [Laughter and applause.]

Now, gentlemen, mark me, I am not disparaging my city. There is no man more loyal to his city and the people in it than I am. I believe I am living in the queen city of the state. But it is not the city, it is the people. [Laughter.] Therefore I say that it is a hardship for us in this city, under its conditions, to try and establish a meter system. I heartily believe in what has been stated here before in relation to a watch or any piece of machinery,—I don't care what it is,—you cannot set it going and let it run without repairing or cleaning it once in a while, and expect to get good results from it. It is so with a meter; it ought to be taken out and cleaned and looked after, and then the result of that meter will be right.

It is not a superintendent's or a water registrar's business how the people use water, but it is his business to see that all get justice, and I don't believe there is any superintendent but is laboring to see that the citizens get justice, though in no

greater measure than the city receives it; that is, equal to all. And so I say that if we are going to reduce the consumption of water in our cities, we must stand the burden of everything that goes with it until we accomplish that result, and the only way we can accomplish it is by being firm and impressing upon the people that we are trying to do what is right by them, and educating them up to that fact, and until we have done that, and not until then, will we accomplish what we are all trying to do, namely, bring down the consumption of water in our cities to a point where it is reasonable.

When you look at it, in the city of Chelsea 82 gallons per capita in November and 173 gallons in these last two months (or since we had have this cold snap), 91 gallons waste per capita going through the sewers, costing $150 a day, for what? To allow men who own houses, — who won't exert themselves to put the plumbing in so as to protect the pipes from frost, — to allow them to accomplish their object at the expense of others who do not have to waste the water in this manner. The work of protecting pipes from freezing can be accomplished in one house just as well as it can be in another if it were not for the fact, as my friend before mentioned said, " You cannot educate them up to it."

MR. JOHNSON. Mr. President, I should like to ask the gentleman who has spoken what the population of Chelsea is?

MR. CASSELL. Thirty-eight thousand.

MR. JOHNSON. And $150 to keep pipes from freezing amounts to about how much per person?

MR. CASSELL. Well, I —

MR. JOHNSON. Less than one third of a cent a day for each person to prevent the plumbing from freezing in the houses.

MR. CASSELL. Yes, but, Mr. Johnson, there are other things to be taken into consideration besides that, which, if I had the time I might state, but I don't think I will take up the time because there is a gentleman waiting to be heard on another matter.

THE PRESIDENT. Keep right on, Mr. Cassell.

MR. CASSELL. Before the Metropolitan Water Works sprung into existence we obtained our water supply from the city of

Boston, and at that time there were periods in the summer and winter when, in order to get a supply of water to take care of the population (and it was a great deal smaller then than it is now), we had to install a pumping-engine and pump from the low-service into a high-service reservoir, and we had to do that in the hours of the night when the population was asleep, and if it had not been for the fact that the Metropolitan water works of the state of Massachusetts had been created, God knows what we would have done for water, — and we don't like it any better than the rest of you at that. [Laughter.]

Now, Mr. Brackett will corroborate what I say, that notwithstanding the fact that the state of Massachusetts has spent $40 000 000 to create a supply of water sufficient for all the cities and towns within a radius of ten miles of the State House, and, according to their best judgment, have put in aqueducts big enough to bring it down, I am informed that if this same waste took place everywhere it would be impossible for them to supply the amount without going further and spending more millions of dollars. So, Mr. Johnson, it is not the one third of a cent, but there are other things connected with it which must be taken into consideration.

Gentlemen, I thank you very kindly and I will close.

Mr. F. H. Hayes.* Mr. President, I have in mind the investigation which has been going on in a town for the last ten days in the matter of displacement of water with our pump. All the water going through the pump is going through a large meter. It is an electrically driven pump, with recording instruments from the General Electric Company, and the displacement of the pump indicates so much more water passing than does the meter that we are going to weir the water to see which is right, whether it is the pump or the meter.

The President. I should like to ask Mr. Hayes what his idea is of average pump slippage.

Mr. Hayes. Three to five per cent.

The President. That is, a new pump?

Mr. Hayes. Yes.

The President. How about an old one?

* Of the Platt Iron Works Company, Boston, Mass.

MR. HAYES. It depends on how gritty your water is.

THE PRESIDENT. How high slips have you known?

MR. HAYES. Oh, up to 50 per cent. You take a plunger pump traveling through a bushing without fiber packing and the slip is more than with the fiber packing. The pump we have in mind is a fiber-packed pump; it is a triplex pump; so we know pretty well that we are displacing the water; but we became so suspicious of the meter that was measuring the water, we have decided to submit it to weir measurement so we may know whether it is the pump or the meter, or where it is.

THE PRESIDENT. Or the weir?

MR. HAYES. Well, that will be up to the engineers.

MR. HENRY V. MACKSEY.* Judging from the arguments offered so far, it would seem that the general impression is that the author desires to prove that the use of meters will not prevent waste of water. I do not so understand the drift of his argument. Although he led us along with facts and figures to show that the first decrease in per capita consumption was not long maintained, he also said that in his opinion the use of meters was necessary and that their installation and use would surely continue. It would therefore appear that he does not differ materially from the many members of this Association who have studied this problem in all its phases for many years.

There is no doubt that many of the reasons offered to-day why meters do not continue to show the marked results secured on first installation are true. That the average meter is accurate and in good working order when first applied is undoubtedly a fact, but it cannot be expected to remain so forever. Water-works superintendents are usually compelled to produce great results on small incomes, and there is always a violent criticism of the cost of meter repairs by those who waste water and consequently despise meters. As the superintendent is usually very busy attending to his principal duty of supplying water at all times to all takers, and is hampered by lack of funds and of skilled labor, he often leaves the meters alone until they cease to register or break down, or prevent the flow of water on account of being stopped by rust or other foreign material. Then, out comes the

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meter. Suppose that the meter had been given as good care as an ordinary machine used in a shop gets; that it had been viewed once a year, or even once in three years, and was tested for accuracy and adjusted if necessary. Trouble and expense would have been avoided and a greater revenue would have accrued to the water department. It should be borne in mind that when a meter fails to do satisfactory work it is not useless. If the mainspring of a watch breaks or it stops on account of dirt, we do not throw it away. A dollar will pay for cleaning, or a new mainspring may be procured for from twenty-five cents to a dollar, depending on who does the work.

To say that the waste necessary to prevent freezing costs but one third of a cent per day per capita may be true, but that is not the proper way to look at the freezing problem. You should not figure on the bill for damage due to frost, in the general case, but on the interest on investment to permanently prevent freezing by proper construction. Mr. Thomas is certainly correct when he says that a dwelling wherein water freezes is usually unfit for human habitation. If we can force owners to so protect the plumbing in the dwellings of the poor that the water will not freeze, we will deserve credit for accomplishing a good work outside of our ordinary field.

That the per capita rate increases again after meters are applied should not discourage water departments. Remember that on a meter basis each taker is being charged for what he takes and no more, and that he can economize or be lavish in the use of water as he sees fit; and above all, let us not forget that the meter is not an instrument designed to discourage the use of water, but to stop waste or penalize the man who is responsible for that waste.

MR. BRACKETT. Mr. President, I should like to ask Mr. Johnson how, if meters do not prevent the use of water to prevent the freezing of the service, does he account for the fact that cities and towns which are universally metered show very little increase in consumption during the winter season, while those which are not metered have, during cold weather, an increase of from 50 to 100 per cent.?

MR. JOHNSON. Mr. President, perhaps my statement was a

little rash. What I meant by this statement was that a man who has a meter in his cellar would not be prevented from allowing the water to run if he thinks the freezing of his pipes would be prevented by that means. It may be that the introduction of meters will cause better plumbing to be put in; I have little doubt about it, not only in regard to freezing, but in other ways. I simply mean that on a particularly cold night, if I think that my water pipes are going to freeze, I will allow the water to run, meter or no meter, knowing that the increase in the water bill will be very small.

MR. J. C. GILBERT.* I have been very much interested in the address, and also in the discussion, but there is one thing which I think we have neglected to look into, and that is this: Supposing none of us had meters, or suppose, for instance, there were no meters; what would have been the increase in the use of water? Of course the people, if they do not have them, are careless with their water; and although you may catch a man once in a while and tell him that he must be more careful, he doesn't care much about that; but if you finally decide to put on meters, then they will see that you are after them and for a time they will be careful.

We have seen by the tables here that after putting on meters the consumption of water has decreased very quickly. One reason for that is because the people see what is coming, and they know that if they use water they have got to pay for it, and for that reason they are more careful.

All the houses that are built at the present day have more fixtures, more plumbing, and, of course, they require the use of more water. But if we hadn't put on meters, you would find that these water-works systems which are paying good dividends would have been in bankruptcy long before this time. I tell you that people would use water to-day at a fearful rate if no meters had been put on. I think we should have been obliged to do something radical to stop the waste. And now, after metering these systems, we find the more fixtures we have in a house the more water they will use, and that, of course, increases from day to day, until it gets up to nearly where it was before meters were put on, but we have nothing to show how much more the increase would have been had no meters been put on.

* Treasurer of Water Board, Whitman, Mass.

I believe in meters; I think that it is the only way to sell water unless you have all the water you want.

In my town last year we used 46 000 000 or 47 000 000 gallons of water, and we put in 85 new services, and we have metered nearly every one of them, and this year, when we came to figure up, we have only used about 42 000 000 gallons. Do you think if we had not metered those services there would have been a decrease in the consumption of water? I do not. I think there would have been a large increase. I believe that meters are a necessity, and I do not believe that the water systems to-day could be run with any kind of profit if it were not for meters. I think it is a blessing to the whole country that they are in use to-day.

MAYOR BLODGETT.* Mr. President, when you called upon me before I had nothing to say, but I have something to say now. I want to say, in the first place, that Mr. Johnson is the only man who has talked to my liking about water.

I want to answer just one question about going into bankruptcy if meters were not used. We have in Woburn not one metered service, but we have a water plant there that is absolutely free from debt. How many cities and towns are there here that can say that? Not one. Our water plant has yielded a revenue of $25 000 a year, and there is now a surplus.

MR. CASSELL. Mr. President, notwithstanding the statements I have made, and the statements that the gentleman made about bankruptcy, and the fact that we use a great deal of water, — notwithstanding all that, we had a surplus of $39 000.

MAYOR BLODGETT. What did you do with the $39 000?

MR. CASSELL. Well, they threw it into what they call the contingent account. It is something like a hole in the ground. [Laughter.] It is like one of those wells to which there is no bottom, and if you can go over there and find out where it went to, I wish you would.

Now, gentlemen, I want to say that I am very grateful to Mr. Johnson for his paper and his talk, and I think I voice the sentiment of every member of this Association. If it hasn't done anything else, it has brought up a discussion, which I think has been very enjoyable and has met with some favor.

* Woburn, Mass.

MR. X. H. GOODNOUGH.* Mr. President, the charters originally granted to cities and towns authorizing them to supply themselves with water, did not contemplate the collection of a profit from the water works. It was assumed that only a sufficient amount would be collected from water rates to pay interest and sinking-fund requirements and the cost of management and operation of the works. The use of the water-works income for other purposes has, in fact, been specifically prohibited in some of the more recent water supply acts. If the latter practice shall become general, the cost of water to the consumer will eventually become very much smaller than it is to-day.

Under these conditions, in New England cities and towns, where the water works are, as a rule, well managed and the consumption of water is not unreasonably large, it can hardly be expected that in the long run any very material reduction in the use of water will follow the general introduction of meters.

Experience with water supplies in Massachusetts shows that there are comparatively few places in which records of the consumption of water are kept where the quantity consumed per person is unreasonably large; while, on the other hand, occasional measurements or calculations have shown that the quantity used in places where no continuous record of the consumption is kept is in very many cases excessive. In some such places the installation of a system for the continued measurement of the total quantity of water supplied to the city or town has been followed by a very material reduction in the use and waste of water without the general use of meters; and there can be no question that an actual knowledge of the quantity of water used leads to the prevention of illegal or unnecessary use and waste by the exercise of greater care and vigilance by the water-works authorities.

There can be no doubt that the general use of meters is a further check upon the excessive waste of water and tends to keep its use within reasonable limits, and the meter system is the simplest and most equitable method of distributing the water tax. It cannot be expected, however, that in places where the consumption of water is not excessive, the introduction of meters will reduce materially the consumption of water, or in places where the con-

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sumption is low, keep it from increasing, when the rates charged for water are diminishing.

MR. THOMAS. Mr. President, of course the reason why Woburn has no indebtedness and has a surplus every year is simply due to the fact that they charge more than they ought to. If every city and every water company in the state of Massachusetts charged more than they ought to, they would have a surplus and no indebtedness. It is all a matter of charging.

MR. FULLER. Mr. President, it occurs to me that there is a great deal more water used to prevent freezing than there is needed for that purpose, and if just enough could be used to prevent that freezing, it would be a very small amount. I have occasionally let the water run to prevent freezing, though not very often, and I was surprised to find how little water it required. I think if the information could be spread abroad among people who allow the running of water to prevent freezing that it requires but very little, it would have a tendency to cut down this waste immensely.

THE PRESIDENT. I am afraid, Mr. Fuller, that the only educator is the meter.

MR. W. H. RICHARDS (*by letter*). The tables presented by Mr. Johnson show, in a marked degree, the impossibility of comparing the consumption of one city with another without knowing all the factors which enter into the problem of per capita consumption. In a city where large quantities of water are used for mechanical or manufacturing purposes the operatives in the factories, who are a part of the population, are apportioned their share of domestic consumption and a portion of the water used for manufacturing purposes, thus raising the per capita consumption. On the other hand, in a city where a large proportion of the inhabitants consist of factory operatives living in houses without sanitary fixtures, where in fact, in many cases, the entire supply for several families is drawn from one faucet, the per capita consumption for domestic purposes is very low. This latter condition obtains in Fall River, and the per capita consumption there is further reduced by the non-use of water for manufacturing. Another factor in the problem is the sudden extension of the sewer system in a city, which often takes place several years after the introduction of water.

There is no doubt that in most of the cities mentioned in the tables there has been a sudden increase in the number of so-called sanitary fixtures in recent years, which tends to largely increase the per capita consumption, and a line in the diagrams showing this increase would probably account for much of the increase in per capita consumption after the introduction of meters. It is usual in most cities to meter all of a certain class of consumers at one time, and when the class where the greatest waste occurs is metered there is a sudden drop in the consumption, as shown on nearly all the diagrams, this showing the beneficial effects of meters in checking waste.

Does any man doubt that if all the meters were removed there would be a sudden increase in waste and a consequent increase in per capita consumption?

With the constantly increasing number of purposes for which water is used, it is probable that the quantity used per capita will increase for many years, but meters alone will keep down the waste and unnecessary uses.

There is one phase of the meter question which is often overlooked, viz., the equity of paying for water in proportion to the quantity used. There is no commodity, except water, which is sold at one price regardless of the quantity used. The injustice would be apparent if two bushels of potatoes were sold to one man for the same money as one bushel were sold to another man. Yet in the case of water at schedule rates the careful man pays not only his proportion of the expense of furnishing water, but also for the cost of furnishing his neighbor with water to waste; whereas under meter rates each pays for the benefit he receives and further pays for his neglect of consideration for his neighbor.

There are many questions in regard to meters which remain to be discussed as to the cost of accuracy, repairs, life, etc., but the fact of their efficacy in reducing waste is established beyond question.

MR. CLEMENS HERSCHEL* *(by letter)*. The error lurking within the paper is one, it seems to me, of a misinterpretation and a wrong use made of statistics. I have always thought that hydraulics was a subject more capable of causing one to deceive

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himself than almost any other, unless it be the recognizing of the true meaning of, or the lessons to be drawn from, statistics; and when it becomes a question of properly using a combination of the two, the opportunities for self-deception become very great.

An inkling of one such error and of a class of such errors was given by President John C. Whitney when he referred to the construction of sewers while the statistics were being taken, and to the consequent change in the water-consuming habits of the people which developed during the statistic time. Mr. Sherman gave another argument against the acceptance of statistics taken in a formative community, — on the wing, as it were, — when he called attention to the fact that following the inauguration of a public water supply in a municipality comes a period in which the citizens learn to use water and put in fixtures to draw water. Naturally no correct use can be made of statistics taken during the course of such an era of water-works extensions without the houses of the people and within them. From data of this sort all those not strictly analogous and sound in every way must first be carefully culled out before they can properly be used in the diagrams made for the determination of facts or laws.

To illustrate: Take Table No. 1, on page 113. What does the paper care for the different characteristics or modes of government of the different cities cited? Some I happen to know something of. There is Bayonne, N. J., the home of the very large works of the Standard Oil Company; which alone, besides the Orford Copper Company and other minor manufacturing concerns, consume millions of gallons of water daily. I doubt if the consumption of water in Bayonne by consumers such as are found in the *average* city of that size is to-day so much as 40 gallons per person, and some years ago it was about 30. Under these circumstances what right has any one to call 100 one coördinate of a pair of rectangular coördinates, and write 95 in the other column for Bayonne, as is done in the table? How many more such defective figures are there in the table? And in the diagrams based on it, and in similar tables?

We are told that Brockton, Fall River, and Providence may likely be found, before long, less of an example to the others than they have been. Will that be on account of a proper increase in

the use, not waste, of water? Or will it be because by change of administration, or similar causes, vigilance and skill in the finding and remedying of leakage and waste of all sorts has relaxed, perhaps joined the majority?

We hope not. For we have largely profited by, and need, more than ever, their bright example.

Is it not all wrong to lay weight on and use, as the basis of diagrams from which to deduce laws, a set of statistics that deal with the effect of metering 25 per cent. of the taps of any one city? What does that teach us of the *character* of the draft from either the 25 per cent. or from the remaining 75 per cent. of the taps?

When left to the consumers it is the wise and thrifty who put in meters, while the shiftless and wasteful fight against them, and prefer to let the others pay for the water they themselves waste.

It will not do to infer merely from statistics taken with a free, liberal hand, and then plotted on an assumed system of rectangular or other coördinates. Instead of this, a lot of thinking about the true and precise meaning of each item, and of culling out, must be kept up to permit of valid deductions being drawn from the finally remaining lot.

It is said that Lord Palmerston, prime minister of England, once called in his chief statistician, wishing to be informed as to pending legislation on, we will say, the culture of rice, and asked him to go and prepare for use the established statistics concerning rice. Much to Lord Palmerston's surprise the man hesitated and hung back, and being asked why he did not go and do as he had been told, blurted out, " But, my lord, what is it you wish to prove? " He had facts enough on file, but according as his statistics were handled and marshaled, they could be made to support one feature of an argument or another.

Can we not do better than limp along in this matter with leaden feet, in the distant wake of uncertain and obsolescent statistics?

Nobody wants to reduce or restrict legitimate use, or cares particularly just where laudable habits of the people will bring it. What we are after — our ideal aim — is the utter annihilation of *waste;* and the complete way to accomplish this is to start fair, or to bring waste to a reasonable figure, and then to maintain that condition; and the way to do this is to make a daily, if

possible, — at all events a short term, — continuous routine comparison between income and outgo. In a paper I expect soon to publish I have said as follows:

The case of the East Jersey's Water Company's fifty miles of pipe line has already been given as an example of water waste prevention by a controlling and checking of leakage as it arises. On that method of work hang all the law and the prophets relating to water-waste prevention in any kind of a hydraulic plant. In the last analysis the prevention of water waste depends on naught but a daily measurement of income and outgo, and the keeping of these two in constant agreement. If a meter be placed at each end of a pipe line 23 miles long, as was done when the conduits of the East Jersey Water Company were built, it is very evident that the daily records of these two meters must agree, or else there is something wrong about either the meters or the pipe line; and if the meters are in order, leaks must be sought for and remedied on the pipe line between them.

In a larger sense the above-described procedure is all that is necessary to control and check waste and leakage on any kind of a pipe-line or system of pipe-lines up to the complex, but to treatment perfectly amenable, case of water supplied to a city district and consumed within it by resident families, shops, and manufactories.

This opens up a large subject, but ill undersood, especially so in the United States, where a street-main leakage of 20 gallons per inhabitant and more is considered an infliction of Providence or due to the climate, or to the peculiar habits of free-born Americans, or to most anything else than to the municipal shiftlessness not infrequently encountered in the United States, or to lack of the proper amount of work expended to control street-main leakage by the water-works administration; which alone has allowed it to grow to the existing serious dimensions through the course of perhaps fifty years of frequent changes of administration.

Nor will spasmodic examinations and reports made upon them change the situation. This is only the old story of house-to-house inspection of plumbing fixtures to prevent waste on the consumers' premises over again, and as applied to the case of cities wasting out of the street-mains. So soon as the inspector's back is turned, waste renews its insidious work and is once more on the increase.

There is only one way to keep control of street main leakage, and that is by a continued system of frequent, or so long as it is necessary, of *daily* measurements; best by means of twenty-four hour chart records, which will serve to note the course of or *the*

beginnings of sources of waste, and by thus first placing and then keeping waste under subjection.

The city should be divided into districts, any one of which could be shut off from the rest and have its supply graphically and continuously measured and recorded at any time, day or night, and as long as desired. Then by well-known means, all consumers should be metered; and once the accuracy of these meters is known, leaks and waste outside of the consumers, premises can likewise be sought for and remedied.

In an examination of this sort once made by Mr. Winslow H. Herschel, civil engineer, a son of the author, the final result was that it would be profitable for the city to meter every tap and also to check waste out of street mains, as thereby that city could be made to supply its then inhabitants, and its future growth of inhabitants as well, for *fifty years*, from the quantity then consumed (used and wasted) within its city limits.

As the situation in the United States in the respects referred to may not be known to the reader, it is proper here to say that one city frequently commits the folly of pumping over 400 gallons per inhabitant per day into the sieve that represents its distribution system, the wide-open plumbing fixtures of its inhabitants included; and 350 gallons per inhabitant is an ordinary quantity to be consumed in that city.

A school of water-works philosophers and bodies of complacent officials have grown up who will argue that 150 gallons per inhabitant is too small a quantity to provide for a city, when half that quantity could readily be reached or approximated; and that city water main waste cannot be reduced to the terms that obtain in Europe; or in the distribution of gas in cities at home (frequently as low as 12 per cent. of the output). Yet all this time the city of Providence, R. I., in the United States, a city of some 200 000 inhabitants, the center of a large suburban district, housing many thousands of transient visitors daily in addition, and a large manufacturing center as well, has never consumed much over 60 gallons per inhabitant per day, and has brought this about by mere ordinary methods of good housekeeping; while smaller places in the United States have approached or reached 30 gallons per inhabitant.

There is room for much good work to be done, so much is evident, and though hitherto the laborers have been few, signs are not wanting and are indeed active that a permanent work of municipal water waste prevention will take up much of the attention of American engineers in the future.

MR. PAUL HANSEN* (*by letter*). This is an exceedingly val-

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uable paper and is the first in which such extensive data have been brought together to show the effect on consumption of metering a public water supply. It is instructive in showing both the advantages and limitations attending the use of meters. With the advantages we are more or less familiar, but the limitations are brought out only by a careful study of facts and are not very apparent from theoretical considerations. Further, the paper brings out, in a striking manner, the value of a pure water supply in reducing waste consumption, an economic advantage that needs to be brought forcibly to the attention of many water-works officials.

Following out the logical lesson of Mr. Johnson's studies, it should be recognized that the apparent failure of meters to reduce water waste is not due to the inability of meters to accomplish this result, but to the fact that nearly all of the supplies considered are imperfectly metered. If on a given water supply *all* services were metered and a good meter also placed on the discharge main from the pumps (or conduit main in case of a gravity supply), the detection of any serious waste would be a comparatively simple matter. This applies equally well to waste of energy through slip of the pumps. The few measurements of slip on water supply pumps in the state of Ohio would indicate 25 per cent. to be the rule, and in one case, and that a pumping engine of no mean size, the slip was 40 per cent.

Furthermore, the universal use of meters involves the keeping of more complete records, which in itself is a great gain, for great sums of money are lost by inefficient operation, which inefficiencies are never discovered for lack of figures to bring them out. While no exact figures are available, an examination by the writer of a large number of water supplies in the state of Ohio has convinced him that many thousand dollars could be saved if only the difference between the actual amount of water pumped and the calculated amount as registered by the pump revolution counters could be ascertained. At least as much more could be saved if the difference between the actual amount pumped and the amount paid for by consumers could be ascertained. If by the universal metering of a supply the waste could be kept down to a reasonable amount, the increase in consumption in all but

a very few exceptional cases would be entirely unobjectionable, for the water used would be paid for and any increase in consumption would then fully justify a corresponding extension of the supply to meet such consumption. Thus, to the writer's mind, the point most forcibly shown in Mr. Johnson's excellent paper is the necessity for the complete metering of supplies in order that the best results may be obtained.

MR. E. M. PECK * (*by letter*). I feel it not only a duty but a privilege to commend Mr. Johnson's paper; and while most of the statements he advances have become fairly well known to active water-works men, I doubt if ever before they have been so comprehensively and convincingly presented as in this paper.

The statement that because meters have accomplished a certain result in one city they need not be expected to accomplish the same results in any other city is eminently true. Every tub must stand on its own bottom, and while results in one city may be taken as an indication of what may be looked for by a similar treatment in other places, a study of conditions prevalent in each city must be made and its salvation worked out independently. In working out the effect of meters upon the consumption of water in any city, and especially in doing this comparatively among different cities, we are at once confronted by the paucity of statistical records. Many very indefinite quantities enter into the problem. For instance, in a city of any considerable size, the non-resident and floating population is an element to be considered. It will be remembered that when Mr. Nicholas S. Hill, as chief engineer of the water department of New York, was making elaborate water-waste surveys in that city, he found in certain sections what appeared to be enormous waste. When an analysis of the population and business enterprises of these sections was made, however, it was found that including the non-resident population the consumption was, in reality, remarkably low.

If my recollection is not at fault, the statement made at that time was that the floating population of Greater New York was estimated at between 500 000 and 600 000. In my own city, after a good deal of investigation, I am accustomed to call the non-resident population equivalent to 3 000 regular water consumers.

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Another common source of error in pumped supplies, where the rated capacity of the pumps is the only means of measurement, is in making wrong allowances for slip.

Where a large percentage of the taps are metered there is danger of arriving at wrong conclusions on account of the under-registration of meters. In my own city not long since, out of 201 meters tested, 31 registered less than 98 per cent. of actual flow, the range of percentages of registration being from 84 to 97.82.

Of the 201 meters above mentioned, 19 registered over 102 per cent. of actual flow, but inasmuch as the worst case exceeded this figure by only 1.73 per cent., it will be seen that the over-registration need hardly be considered.

In figuring upon leakage and waste, sight is lost frequently of private fire-service pipes. In my own opinion, if these were either all metered or subjected to rigid control of some kind, many a water-works department would be able to make a much closer accounting for its water than it now can.

There is no doubt whatever, as Mr. Johnson says, that the first effect of meters when set in considerable numbers is to reduce the consumption. For a short time they seem to frighten the consumer into exercising the greatest care, not only in the necessary use of water, but in keeping plumbing in repair as well. After he receives a few bills under the meter system he is apt to discover that if anything he is paying less than under assessment, and his care at once relaxes, with the result that consumption increases.

That what might be called the necessary consumption of water is increasing, I think there is no doubt. I also doubt if any meter system will reach its highest efficiency in reducing consumption unless coupled with a rigid leak inspection both inside and outside the premises.

Metering of the city of Hartford was begun in 1900 and completed in 1903. According to the best information at my command the per capita consumption before general metering was commenced was about 84.6 gallons. Since that time the average per capita consumption by years has been as follows: 1901, 75.5; 1902, 77.2; 1903, 74.2; 1904, 66.4; 1905, 62.8; 1906, 64.7.

It will be noticed that the most remarkable decrease in consumption occurred in the year following the completion of metering, 1904.

During this year and since that time, however, a very thorough investigation for leaks all over the distribution system has been maintained, which I think accounts for the sudden drop. The consumption of the year 1906 would indicate that in spite of meters and leak inspection, increased use of water is making itself felt.

In this connection, however, I will say that my opinion is that the population of the city has increased much more than we suppose, and that if the true figures were known the apparent per capita would be somewhat reduced.

MR. MORRIS KNOWLES * (*by letter*). The Association is fortunate in having presented so clearly much valuable information regarding this problem which, while it has long been before us, is yet little understood by the mass of the people. The author deserves our thanks for his labor and painstaking care in bringing out important data, some of a novel kind, and the deductions from them.

The writer does not agree with all the conclusions, but neither does he believe, with some, that this article, written with these ideas, will do harm and create a sentiment against metering. There is some popular cry against the use of meters, due to many different causes, but this is not general among those who intelligently look into all phases of the subject, unless political or personal financial reasons cause a bias. The truth cannot hurt, and facts honestly presented and intelligently discussed can operate only for good. If the facts now brought out should indicate that metering is not so valuable as has previously been supposed, no amount of blind following of old dogmas will long keep the proper light hidden; thoughtful consideration is best.

The writer, however, does not believe that the facts show a failure in meters to do that which may properly be expected, namely, to reduce the waste and improper use of water and to prevent an extravagant increase. For a long time many have anticipated too much from metering alone, and it is but reasonable that thoughtful consideration of facts will show that other investigations and rigid inspections should go hand in hand with the general introductions of meters. Furthermore, while the general

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use of water is increasing, due to the several causes mentioned by the author, and most of all due primarily to the prosperity of the country and the general lavish conduct of the American people, waste and excessive increase are checked by the use of meters, especially if other precautionary measures be adopted.

Several years ago, in considering the use of water for the city of Pittsburgh, the writer, in coöperation with Mr. A. B. Shepherd, superintendent of the Bureau of Water, made an estimate of the probable saving that could be made with the introduction of meters and careful restrictive measures and investigations. Considerable criticism developed, due to the fact that the capacity of the filtration works was based upon an ultimate figure of 125 gallons per inhabitant per day, and that the works should be prepared to deliver at first the amount of water then being used. Many persons, believing that two thirds of the water was wasted, thought that the use of 253 gallons per person per day at that time should be brought down to about 85. This is but an example of two great expectations, — a forgetfulness that certain places may naturally use more water than others, and also that works should be designed for that which is rather than for that which should be.

At the time of making these estimates for the city of Pittsburgh, data were secured from most of the cities in this country having more than 25 000 population, and this information was plotted to show the relation between the per cent. of services metered and the daily use of water per inhabitant. This diagram has recently been brought down to date and it is reproduced in Plate II. The most important thing to engage attention is that the recent knowledge does not materially change the general appearance of the diagram. For the purpose of comparison, the average line made up from Mr. Johnson's data for five groups is plotted as RST.

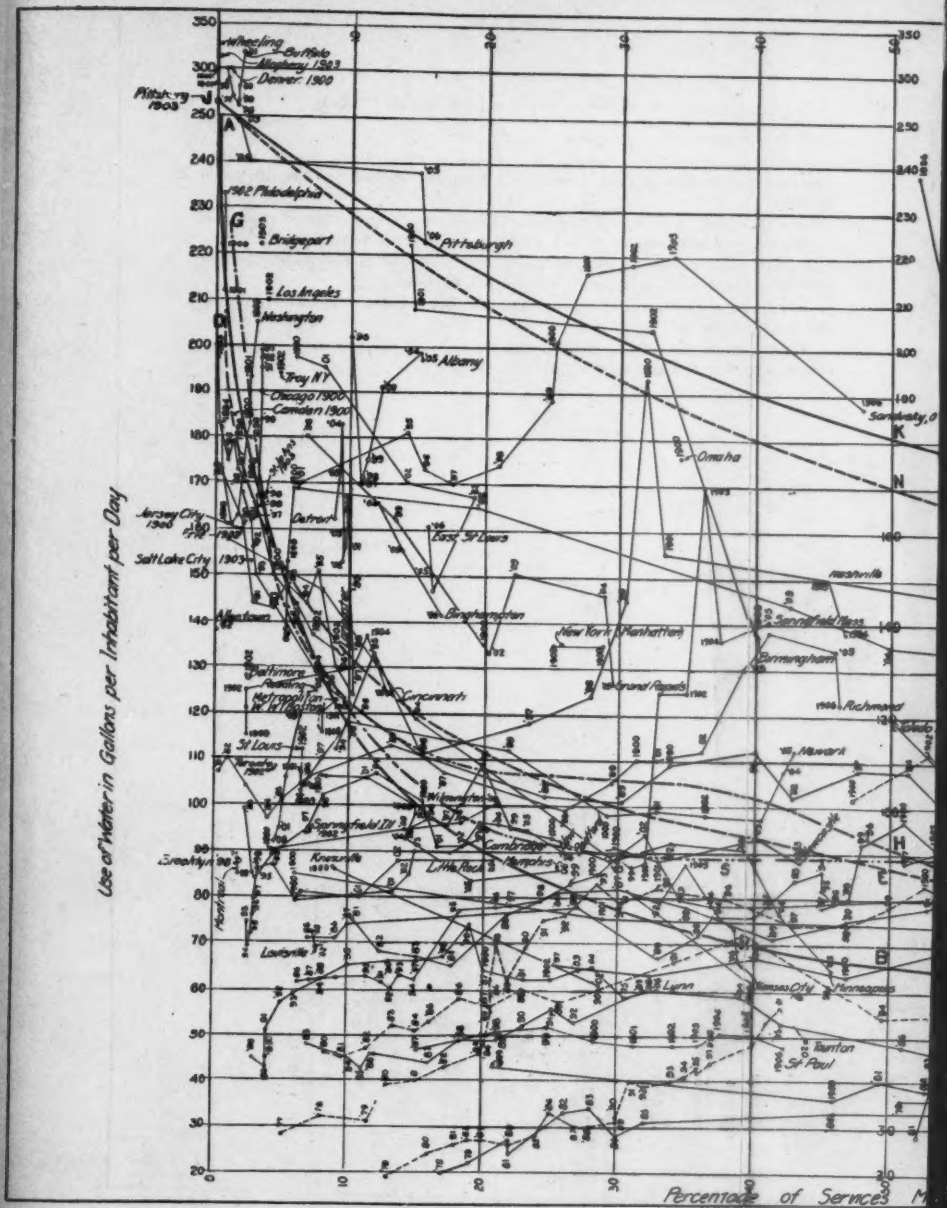
The completed line for the city of Pittsburgh for the last few years is particularly instructive, and it is remarkable and seems almost beyond belief that for the year 1906 the line strikes almost exactly upon the point predicted under normal conditions of introducing meters.

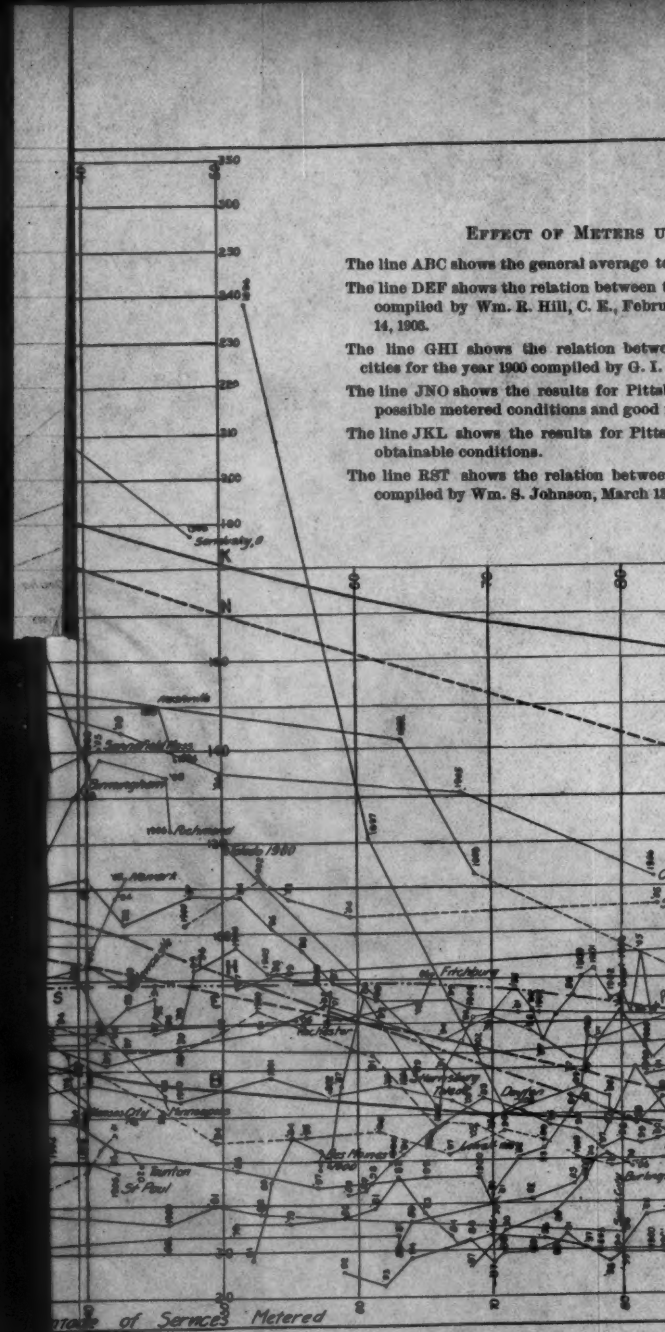
A few words may not be amiss about the slope of this line. It

is probable that the 1903 stated use of water was too high; the over-estimate was due to the fact that for a long time the pumps had been working without much rest for overhauling and repairs, and the turbid and gritty water had developed a large amount of wear in the valves, and thus a large amount of slip and an over-estimate of the pumpage. With the addition of two new pumping engines, made available in 1904, and the slip thus reduced, it will be seen that there was a sudden drop in the use of water per person. The new figure was probably the more correct one for the previous year or two. Meters have been introduced, and out of a total number of about 6 500, very nearly one third are in one district, using one twentieth of the water. The marked drop during the last year has also, in part, been due to a thorough pitometer investigation and house-to-house inspection, mostly in this same district.

It may be of interest to give the statistics of this district, which is a good example of what can be accomplished, not only with thorough metering, but even after, by a careful study of the losses in the mains and by a house-to-house inspection. This district, which comprises a certain high territory supplied from the Bedford reservoir, is one which is easily separated for this purpose; and by the courtesy of Mr. A. B. Shepherd, superintendent, the writer is enabled to present this valuable information. It should be remembered, however, that while meters have been largely introduced, payment is still made at the fixture rate, there being no ordinance compelling the purchase of the water by meter. The following are the statistics of this district:

Size of the Bedford District.....286 acres.
Population, estimated to be the same as at the census of 1900..27 241 persons.
Population supplied through meters.....16 800 persons.
Number of houses.....3 773
Number of services.....2 580
Average population per house.....7.2 persons.
Average population per service.....10.5 persons.
Water mains in the district.....13.5 miles.
Population per mile of main.....2 016 persons.
Services per mile of main.....191
Character of district, tenements; plumbing, old and generally poor.
Daily quantity of water entering the district at beginning of the investigation, August 1, 1906.....4 325 000 gallons.


Use of Water in Gallons per Inhabitant per Day
Percentage of Services M
Wheeling
Buffalo
Allegheny 1903
Denver 1900
Pittsburg 1903
1902 Philadelphia
Bridgeport
Pittsburgh
Los Angeles
Washington
Albany
Troy N.Y.
Chicago 1900
Camden 1900
Omaha
Jersey City 1900
Detroit
East St Louis
Salt Lake City 1903
Binghamton
New York (Manhattan)
Springfield Mass.
Harrisburg
Birmingham
Richmond
Grand Rapids
Scranton
Baltimore
Reading
Metropolitan
St Louis
Newark
Wilmington
Springfield Ill.
Cambridge
Memphis
Little Rock
Brooklyn
Knoxville
Louisville
Lynn
Kansas City
Minneapolis
Taunton
St Paul


EFFECT OF METERS U
The line ABC shows the general average t
The line DEF shows the relation between
compiled by Wm. R. Hill, C. E., Febru
14, 1908.
The line GHI shows the relation betwe
cities for the year 1900 compiled by G. I.
The line JNO shows the results for Pitts
possible metered conditions and good
The line JKL shows the results for Pitts
obtainable conditions.
The line RST shows the relation betwee
compiled by Wm. S. Johnson, March 1
Scranton, P
Birmingham
Richmond
Fitchburg
Burton
St. Paul
of Services Metered

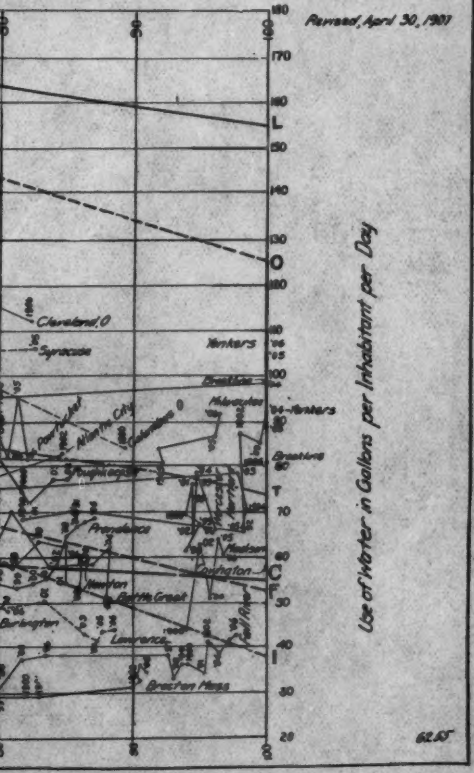
ERS UPON THE USE OF WATER.

rage tendency only.

tween the averages of five different groups of cities
February 25, 1903. See *Engineering Record*, March

between the averages of four different groups of
y G. I. Bailey in *Engineering News* of April 18, 1901.
Pittsburgh, Pa., predicted in 1904, under the best
good restrictive methods.
r Pittsburgh, Pa., predicted in 1904, under probable

between the averages of the five different groups
arch 18, 1907.



Daily quantity of water entering the districts at close of the investigation, April 19, 1907.....3 025 000 gallons.
Saving per day.....1 300 000 gallons.
Per cent. of water saved.....30
Per cent. of services metered.....74.8
Per cent. of water measured by meter.....43.7
Water used per person per day before investigation.....158 gallons.
Water used per person per day after investigation.....111 gallons.

From the known night waste it is estimated that one third of the 111 gallons is still a constant loss.

In Fig. 14 there is shown, in a graphical way, the results in this same Bedford district, showing the decrease in the use of water per inhabitant, month by month, and the corresponding increase in the per cent. of services metered. The latter months of the diagram show the further decrease, as detailed in the above tabulation, with the per cent. of services metered remaining the same.

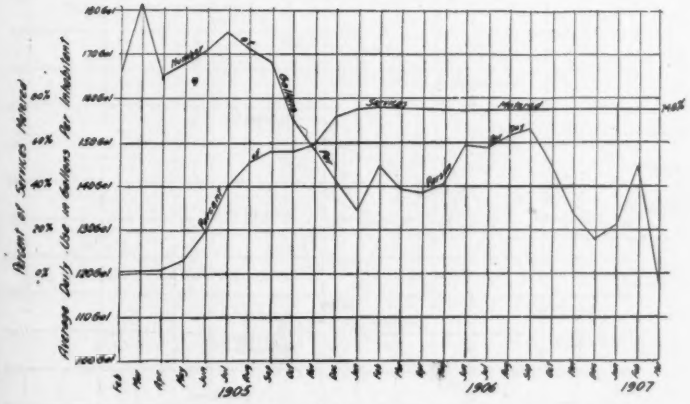
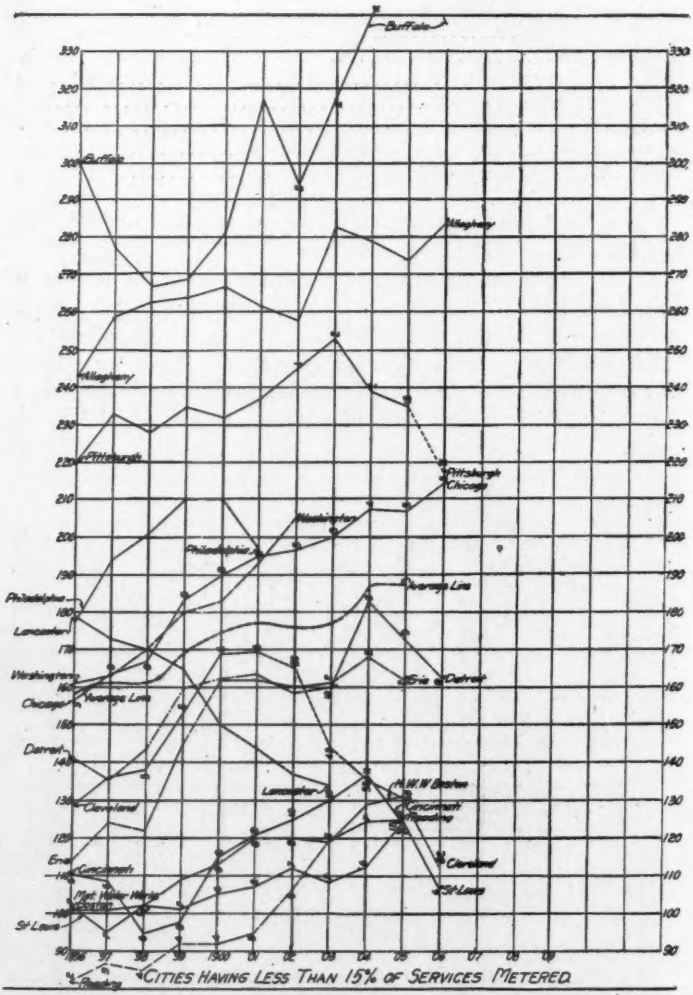


FIG. 14. EFFECT OF METERING AND INVESTIGATION WORK IN BEDFORD DISTRICT, PITTSBURGH, PA.

As a further study into the problem of what metering means to cities, we have plotted, in Figs. 15 and 16, results from various cities in the country. These are divided into two groups; Fig. 15 contains those in which less than 15 per cent. of the services



F.G. 15. FLUCTUATIONS IN THE PER CAPITA USE OF WATER IN CITIES WITH SMALL PERCENTAGES OF SERVICES METERED.

are metered; and Fig. 16 those in which more than 50 per cent. of the services are metered.

The most striking result is the very large consumption in the first group and also the erratic behavior of the lines, showing probably that spasmodic efforts have operated to reduce the

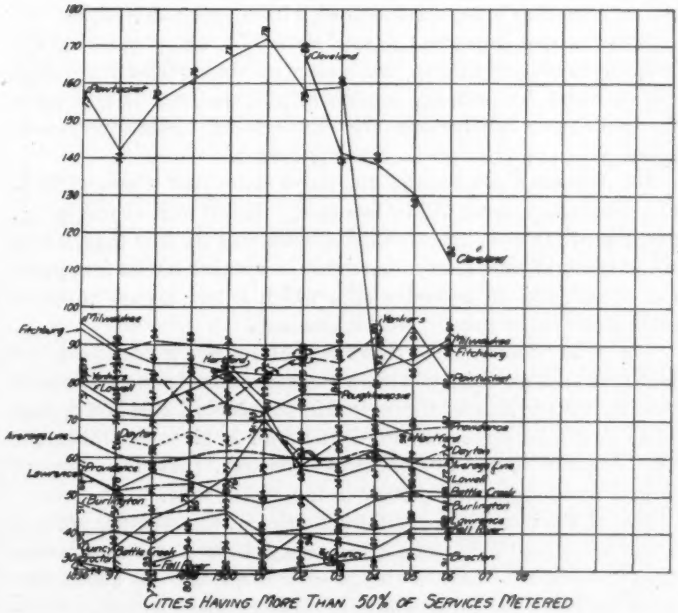


FIG. 16. FLUCTUATIONS IN THE PER CAPITA USE OF WATER IN CITIES WITH LARGE PERCENTAGES OF SERVICES METERED.

waste. In the second group it is to be noticed that the use of water is low, with two exceptions, and the lines follow about the same course, showing but little increase, if any.

The average line in the first group increases 29 gallons in ten years, while the average line of the second group decreases 8 gallons in the eleven years. The latter does not include the effect of the two erratic cities at the top of the diagram. This would

seem to give other evidence than that shown upon Mr. Johnson's Fig. 1. The writer, however, does not pretend to say that metering alone will always cause a reduction, or that, without increasing the use of meters, the line of the use of water will not have a general tendency upward. Eternal vigilance is the price to pay for curtailing waste and keeping an increase in the use of water, as well as other commodities, within reasonable limits.

There is one important factor shown by all of these recent investigations, and that is, that meters do not curtail a reasonable use of water for ordinary household purposes. It is important to dwell upon this because the advocate of meters frequently meets with opposition from this standpoint.

Mr. Johnson has advanced the novel claim that where water is of good quality, there will be less used. This is worth considering, and the writer has already called attention to the fact that, where water is muddy and gritty, there may be another reason for apparent excess, due to excessive slip, which is not always properly estimated and frequently not high enough.

The writer cannot agree that the winter waste is negligible, nor is it true that all cities will show the same months for increase as that shown for Massachusetts in Mr. Johnson's Table No. 6, page 129. A similar statement for Pittsburgh is given in Table No. 13. Another truth is not shown, namely, that the days of largest pumpage are frequently in the winter time.

One of the last items mentioned, namely, that the per cent. of water accounted for is small, has always been a startling revelation to those who have investigated this matter. It shows that there are likely to be places of large waste besides the house plumbing, and this is a strong argument for other means of investigation and for large meters upon the principal water mains supplying given districts, so that the total quantities coming into a district can be determined.

The writer is glad to heartily concur in the closing paragraphs of the author, and to express the belief that by the dissemination of such data we will come to a more thorough understanding of this interesting problem.

TABLE No. 13.

PER CENT. WHICH MONTHLY USE OF WATER IS OF THE AVERAGE, TOGETHER WITH AVERAGE RAINFALL AND TEMPERATURE FOR PITTSBURGH. (AVERAGE OF ELEVEN YEARS, 1896–1906.)

	Per Cent. of Average Use of Water.	Rainfall. Inches.	Temperature. Degrees Fahr.
January	98.8	2.14	31.1
February	103.8	2.29	29.0
March	101.3	3.90	41.4
April	99.1	2.96	51.2
May	97.7	3.03	63.9
June	99.5	4.61	70.5
July	102.0	3.99	75.3
August	102.3	2.94	73.4
September	102.0	2.14	67.6
October	98.7	2.29	56.5
November	96.4	2.22	44.1
December	99.7	2.63	33.3

MR. JOHNSON (*by letter*). Judging from some of the foregoing discussions, certain of the conclusions in my paper cannot have been clearly stated. I have not attempted to show, nor have I suggested, that meters do not reduce the waste of water in houses. What I have shown is rather that high consumption does not necessarily mean wastefulness on the part of the consumer, and that it cannot, in all cases at least, be reduced to a low figure by the introduction of house meters. I am very far from condemning meters as being worthless, but rather would condemn the extravagant claims made as to what they will accomplish.

It is unfortunate that in order to secure the introduction of meters, water-works officials so often find it necessary to make claims as to the great economy in their use which cannot be substantiated. As a matter of fact, there are much better reasons why meters should be used than the mere reduction in the consumption of water, and even if it is found to be cheaper, as in some cases it will be, to supply the excessive quantity of water wasted than to install and maintain meters, yet the use of meters is justified in order that the cost of the water may be equitably assessed. Mr. Richards has expressed this very well in his discussion.

In an effort to accomplish a reform we are too apt to see only those facts which are favorable, shutting our eyes to those less favorable. The cases of Fall River and Brockton are always cited, but we seldom have brought to our attention the many cases where meters are in general use but the consumption remains high. In this paper all of the places concerning which information could be obtained have been included and the facts are presented for what they are worth.

Mr. Brackett in his discussion has unconsciously emphasized the point which I have tried to make in regard to dangers in the selection of certain facts while ignoring others which are equally applicable. He speaks of the high winter consumption in the cities of Boston and Chelsea, which are practically unmetered, and compares the consumption in these places with the low winter consumption in the metered towns of Belmont, Malden, Milton, and Watertown. That the low winter consumption in the latter places is not due to meters alone can be shown by a comparison with the consumption in other cities in the Metropolitan District where meters are not used and yet there is no excessive consumption in winter. The following table is introduced to supplement Mr. Brackett's table by giving *all* the facts. The figures are taken from Mr. Brackett's discussion.

	Per Cent. Services Metered, 1906.	Average Nov. and April, 1906 (Gallons).	Average Four Winter Mos. in 1906 (Gallons).
Boston	5	143	160
Somerville	19	82	88
Malden	78	49	50
Chelsea	10	87	109
Everett	2	73	86
Quincy	3	99	104
Medford	8	93	94
Melrose	3	106	109
Revere	4	67	75
Watertown	93	66	60
Arlington	22	74	73
Milton	100	42	38
Winthrop	2	97	102
Stoneham	2	67	64
Belmont	100	53	44
Lexington	2	71	61
Nahant	18	71	69
Swampscott	0	73	74

Mr. Brackett's statement that in places having a population of less than 50 000 the average per capita consumption should not exceed 50 gallons I will not dispute, but the fact remains that it *does* exceed this amount, and even in the Metropolitan District, as shown by Mr. Brackett's table, there is only one town having a consumption less than 50 gallons per person per day. Furthermore, as stated in the paper, the use of water is increasing at a rapid rate notwithstanding the use of meters, and we must face the fact that if the consumption is to be reduced to 50 gallons per person, it will not be by the use of domestic meters alone. As Mr. Knowles has said, "Works should be designed for that which *is* rather than that which *should be*."

Mr. James H. Fuertes, in his recent report to the Merchants' Association of New York, has made an excellent analysis of the use and waste of water in New York City, and his conclusion is that while a much larger quantity of water is wasted in various ways, the maximum reduction which can be expected by the general use of meters is 15 gallons per person per day. This I am convinced is a reasonable figure to apply to the average unmetered city where the consumption is from 75 to 100 gallons and where there are no unusual conditions.

The point raised by Mr. Sherman as to the increase in the per capita use of water with the age of the works is a good one, and the following table, giving the average consumption in a large number of places, is presented to show the rapid increase in the use of water in the years immediately after the construction of works, due probably in a large measure to the increase in the number of consumers:

TABLE SHOWING INCREASE IN CONSUMPTION OF WATER, WITH AGE OF WORKS.

Year after Water was Introduced.	Consumption. Gallons per Person per Day.
1	22
2	27
3	34
4	36
5	40
6	40
7	38
8	41
9	41
10	42

Mr. Whitney has suggested the effect of the introduction of sewers upon the consumption of water, and the following table is presented which gives the best data which I have been able to obtain in regard to this. The difficulty in collecting such data is that in most cases the sewerage system is of gradual growth, and there are few places where it can be said that in a certain year a complete sewerage system was introduced.

TABLE No. 14.

CONSUMPTION OF WATER IN FIVE CITIES AND TOWNS BEFORE AND AFTER THE INTRODUCTION OF A FAIRLY COMPLETE SYSTEM OF SEWERS.
(GALLONS PER PERSON PER DAY.)

City or Town.	Year Previous to Introduction of Sewers.							Year when Sewer System was Practically Completed.	Year Subsequent to Introduction of Sewers.					
	7	6	5	4	3	2	1		1	2	3	4	5	6	7
Marlborough	13	17	20	21	24	24	25	26	30	30	35	34	37	37	38
Newton	28	31	33	33	31	36	40	42	50	52	60	65	63	60	57
Waltham	37	36	39	33	31	32	33	40	47	53	61	59	71	70	76
Natick	27	29	34	37	40	41	43	46	41	40	42	40	38	42	51
Woburn	60	51	58	54	56	65	69	73	72	68	70	78	78	82	85
Average	33	33	37	36	36	40	42	45	48	49	54	55	57	58	61

A NOTE ON THE SPONTANEOUS IGNITION OF GAS FROM SEWAGE.

BY PROF. W. P. MASON, DEPARTMENT OF CHEMISTRY, RENSSELAER POLYTECHNIC INSTITUTE, TROY, N. Y.

[*Contributed April 17, 1907.*]

At the time of presenting my suggestion that phosphine was probably the agent that ignited the gas mixture in the Saratoga septic tank, which resulted in an explosion that wrecked the structure,* I was not possessed of any data in support of the proposition excepting my observation of gas bubbles which burst into flame as they escaped from the water off the New York docks. I am now in receipt of a letter from Mr. J. H. Fewell, superintendent of the Water Company at Jackson, Miss., in which he says:

"Through the kindness of some fellow member of the American Water Works Association I received a copy of the proceedings of the New England Water Works Association and carefully read your article in reference to the cause of the explosion which wrecked the septic tank at Saratoga, N. Y. It seemed from the discussion which followed that some of your fellow members were a little in doubt as to the correctness of your theory. Some time ago I was out on Pearl River near this city and near our pumping station. There I witnessed a very curious phenomenon. I observed some distance from the shore a great many very large bubbles which came rushing up from below, and when each one reached the surface it burst and a greenish flame would shoot up several inches. I watched it for quite a period of time and was much interested to know about the cause and to have it explained to me, so your theory is timely."

This would seem like some confirmation of my contention. Doubtless the phenomenon occurs but seldom, because of adverse conditions, and one might readily grow weary of watching for it at a sewer outfall, but such an occurrence is apparently not unknown, and it is the part of wisdom to bear in mind the possibility of its happening.

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*Journal N. E. Water Works Association, March, 1907, p. 23.

PROCEEDINGS.

March Meeting.

Hotel Brunswick,
Boston, March 13, 1907.

The March meeting of the Association was held at the Hotel Brunswick, Boston, at 2 P.M., on Wednesday, March 13, 1907.

President John C. Whitney presided, and the following members and guests were in attendance:

Members.

S. A. Agnew, C. H. Baldwin, L. M. Bancroft, F. A. Barbour, J. W. Blackmer, C. A. Bogardus, George Bowers, Dexter Brackett, G. A. P. Bucknam, George Cassell, C. E. Chandler, J. C. Chase, C. E. Childs, R. C. P. Coggeshall, M. F. Collins, W. R. Conard, A. W. Cuddeback, L. E. Daboll, John Doyle, H. P. Eddy, I. T. Farnham, F. F. Forbes, A. N. French, F. L. Fuller, E. F. Garvey, J. C. Gilbert, A. S. Glover, X. H. Goodnough, F. W. Gow, E. H. Gowing, R. A. Hale, J. O. Hall, G. W. Hawkes, T. G. Hazard, Jr., J. L. Howard, W. S. Johnson, E. W. Kent, Willard Kent, G. A. King, Morris Knowles, C. F. Knowlton, E. E. Lochridge, A. R. McCallum, H. V. Macksey, N. A. McMillen, D. E. Makepeace, A. E. Martin, John Mayo, F. E. Merrill, William Naylor, O. E. Parks, C. A. Perkins, H. E. Perry, W. H. Richards, L. C. Robinson, Ransome Rowe, H. E. Royce, A. T. Safford, H. W. Sanderson, A. L. Sawyer, E. M. Shedd, C. W. Sherman, G. H. Snell, G. A. Stacy, W. F. Sullivan, L. A. Taylor, R. J. Thomas, W. H. Thomas, J. L. Tighe, J. A. Tilden, D. N. Tower, C. A. Townsend, W. H. Vaughn, C. K. Walker, R. S. Weston, J. C. Whitney, F. I. Winslow, G. E. Winslow. — 79.

Associates.

Harold L. Bond Company, by Harold L. Bond; Builders Iron Foundry, by F. N. Connet; Coffin Valve Company, by H. L. Weston; The Fairbanks Company, by F. A. Leavitt; Hersey Manufacturing Company, by Albert S. Glover, J. A. Tilden, W. A. Hersey, and H. V. Macksey; International Meter Company, by Samuel Harrison; Lead Lined Iron Pipe Company, by Thomas E. Dwyer; Ludlow Valve Manufacturing Company, by H. F. Gould; H. Mueller Manufacturing Company, by George A. Caldwell; National Meter Company, by Charles H. Baldwin and J. G. Lufkin; Neptune Meter Company, by H. H. Kinsey; The Platt Iron Works Company, by F. H. Hayes; Rensselaer Manufacturing Company, by F. S. Bates and C. L. Brown; A. P. Smith Manufacturing Company, by Fred N. Whitcomb; Thomson Meter Company, by Edward M. Shedd; Union Water Meter Company, by F. E. Hall and F. L. Northrop;

United States Cast Iron Pipe and Foundry Company, by Frank W. Nevins; R. D. Wood & Co., by William F. Woodburn. — 24.

GUESTS.

James G. Hill, water commissioner, Lowell, Mass.; E. T. Harvell, water commissioner, Rockland, Mass.; C. D. Baker, superintendent, Abington, Mass.; C. W. Gilbert, and William E. Blodgett, Mayor, Woburn, Mass.; Sumner W. Hildreth, engineer, Westfield, Mass.; J. B. F. Breed, Esq., chief engineer, Commissioners of Sewerage, Louisville, Ky.; William A. Breed, superintendent, Norwich, Conn.; Major E. S. Horton, Carl G. Kritson, Attleboro, Mass.; Mr. George W. Stiles, superintendent, and Charles T. Hall, water commissioner, Malden, Mass.; F. L. Clapp, superintendent, Stoughton, Mass.; E. H. Palmer, Reading, Mass.; A. E. Blackmer, Plymouth, Mass.; J. B. Newhall, Stapleton, S. I. — 16.

[Names counted twice — 7.]

THE PRESIDENT. We have a guest with us who has consented to address us briefly. I have the pleasure of introducing Mayor Blodgett of Woburn.

MAYOR WM. E. BLODGETT. I have had occasion in my life sometimes to feel the influence at the polls and elsewhere of the liquor dealers' association, but this is the first time that I have ever come under the influence of the water dealers' association; but so far as my experience goes I would prefer the water cure to the other.

I suppose I am called upon here as a sort of a horrible example. Last year my friend Mr. C. W. Gilbert, who has conceived it to be his function in life to convert me and to bring the city of Woburn around to what he considers real righteousness in the serving of water, brought in to us a horde of fellows to tell us that we knew nothing, and they demonstrated that to their own satisfaction; the chief among them is my friend Mr. Whitney, your President. For months I sought in vain for an opportunity to get back at him, but a certain article in the Boston *Herald*, just prior to my own inauguration, led me to look into some things in his own city; and I had occasion, to my own satisfaction at least, to even up with him. The particular grievance he has got against us is that we do not have any meters, and we have no use for water meters, and we have never had any lack of water, except to give a banquet to them, such as I have had with you to-day.

I congratulate you on the work that you are doing.

MR. E. H. GOWING. Mr. President, two months ago I was down in New Orleans and there I met a man whom many of you know, Colonel Gardiner. I have a recollection of a speech that he made in Boston some years ago at a meeting of the American Water Works Association. He wished me when I got back to remember him cordially to all those he knew and who knew him.

Mr. Wm. S. Johnson, assistant engineer, Massachusetts State Board of Health, read a paper entitled "Some New Facts Relating to the Effect of Meters on the Consumption of Water." It was discussed by Messrs. George A. King, Charles W. Sherman, Walter H. Richards, Dexter Brackett, R. J. Thomas, Frank L. Fuller, George Cassell, F. H. Hayes, Henry V. Macksey, J. C. Gilbert, X. H. Goodnough, and Mr. Johnson.

On account of the lateness of the hour the paper by Mr. F. A. Barbour, which had been announced for this meeting, was, with Mr. Barbour's consent, postponed until the September meeting.

The Secretary read applications for membership from the following persons:

William W. Lewis, water commissioner, Hyde Park, Mass.; Samuel W. Hoyt, Jr., resident engineer, Water Filtration Plant, South Norwalk, Conn.; George A. Nelson, assistant city engineer on Water Works, Lowell, Mass.; Howard M. King, assistant engineer, Water Department, Springfield, Mass.; Leland G. Carlton, Springfield, Mass.; Walter Wood, treasurer, engineer, and manager, Millville, N. J., and Owego, N. Y., water companies, Philadelphia, Pa.; S. E. Killam, Reading, Mass.; John C. DeMello, general foreman Distributing Department, New Bedford Water Works, New Bedford, Mass.; David S. Rundlett, superintendent Water Works, Watertown, Mass.; Edward L. Hatch, general manager Stamford Water Company, Stamford, Conn.,

all of whom had been recommended for election by the Executive Committee.

On motion the Secretary was authorized to cast a ballot for the Association in favor of the applicants, which he did, and they were declared elected to membership.

The meeting then adjourned.

EXECUTIVE COMMITTEE.

BOSTON, MASS.,
March 13, 1907, 11.30 A.M.

Present: President J. C. Whitney, and members George W. Batchelder, L. M. Bancroft, R. J. Thomas, D. N. Tower, George A. King, A. E. Martin, George H. Snell, Charles W. Sherman, and Willard Kent.

Ten applications for membership were received and recommended for admission.

The record of the last meeting of the Executive Committee was read and approved.

Application received and laid on the table at last meeting of the Executive Committee was discussed without action.

Committee on June excursion reported in favor of Gloucester, Mass. Report was accepted and committee continued.

On motion of Mr. Bancroft, seconded by Mr. Snell, the President, Editor, and Secretary were made a Committee on Publicity.

Six members previously dropped for non-payment of dues were by vote reinstated, their dues having been paid in full.

Place of next annual convention was discussed without action.

Voted: That the President and Secretary be a Committee on Hotel Accommodations for the next winter meetings.

Adjourned.

WILLARD KENT, *Secretary.*

OBITUARY.

VALENTINE C. HASTINGS, vice-president of the Association, and superintendent of the Concord, N. H., Water Works, died at his home in that city on March 14, 1907.

He was born in Waterford, Vt., February 26, 1838. In 1867 he entered the employment of the Cement-Lined Water Pipe Co. of Springfield, Mass. In 1869 he took charge of a similar company in Manchester, N. H., and a short time later he went to Concord to superintend the construction of the water works system. In April, 1873, he was elected superintendent of the Concord Water Works, and held that position until his death. His ability and fidelity are attested by the long period of service in this office.

Mr. Hastings had at various times held a number of positions of trust and honor in business and church circles, and was a member of the state legislature in 1887. He leaves a wife, three daughters, and one son. The Concord *Daily Patriot* said of him: "As a good citizen and a man of steadfast friendship he will be greatly missed."

Mr. Hastings was elected a member of this Association on June 10, 1886. He served as one of the vice-presidents several years ago, and was again elected to that office at the last annual meeting.

MYRON EDWARD EVANS, C.E., president of the Cape Breton Railway of Canada, was killed in the wreck on the New York Central & Hudson River Railroad at Bronx Park, New York City, on February 16, 1907.

Mr. Evans had an office in New York City and was on his way to his home in White Plains, N. Y., when the accident occurred. He was a graduate of the Rensselaer Polytechnic Institute, Class of 1895, and was an associate member of the American Society of Civil Engineers. He was elected a member of the New England Water Works Association June 13, 1900.

JOHN F. J. MULHALL, water-works accountant and treasurer of several water companies, died on June 9, 1907, following an operation for appendicitis.

Mr. Mulhall was born in Boston on December 3, 1862. He was graduated from the Boston English High School in 1880. His first employment was as clerk in the Boston Railroad Clearing House. Later he studied shorthand under the Hon. Stephen O'Meara, the present police commissioner, then editor of the Boston *Journal*. For some years he was in the office of the Boston Water Board, and in 1885 entered the employ of Wheeler & Parks, engineers and operators of water companies. After the dissolution of that firm Mr. Mulhall remained with Mr. William Wheeler as accountant, and was treasurer of several of the water companies of which Mr. Wheeler is general manager. More recently he had also done private work as an expert accountant. In 1906 he published a book entitled "Quasi-Public Corporation Accounting and Management."

Mr. Mulhall was a member of the Boston Common Council in 1889 and 1890. He is survived by a wife and ten children.

He was elected a member of the New England Water Works Association, November 14, 1900.

BOOK REVIEWS.

THE VALUE OF PURE WATER. By George C. Whipple. viii + 84 pp. 5½ x 8 inches. New York: John Wiley & Sons. $1.00.

This little book unquestionably fills a long-felt want. It represents an attempt to express in terms of dollars and cents the depreciation suffered by a contaminated or otherwise objectionable water in comparison with one which is absolutely pure and unobjectionable.

As the author says in his preface, "The financial standard is certainly not the highest one for judging the quality of a water supply when the public health is concerned; human life cannot be estimated in gold dollars, and the smell of unsavory water to a thirsty man cannot be reckoned in dimes; nevertheless, the financial basis is a convenient one, and one necessarily involved in all questions which relate to public utilities."

No one is more competent than Mr. Whipple to speak upon this subject with authority, as is well known to the members of this Association. The matter is presented in Mr. Whipple's usual clear and logical style, and is so well presented that it makes a very readable as well as a very valuable book.

OUTLINES OF PRACTICAL SANITATION. By Dr. Harvey B. Bashore, Inspector for Pennsylvania Department of Health. vi + 208 pp. 5 x 7½ inches. New York: John Wiley & Sons. $1.25.

This is a very interesting little book for the general reader and contains much valuable sanitary information. One chapter of twenty-five pages is devoted to water supply. This is probably as much space as proportionally belongs to this subject in a book of this size on general sanitation. The importance of sanitary surveys of watersheds is clearly set forth, and the sanitary significance of various substances in or properties of water are well presented.

WATER-WORKS MANAGEMENT AND MAINTENANCE. By Winfred D. Hubbard and Wynkoop Kiersted. vi + 429 pp. 6 x 9 inches. Many illustrations. New York: John Wiley & Sons. $4.00.

A book on water-works operation and maintenance has been needed for a long time, and it is therefore a pleasure to welcome this work, which contains a great deal of data not otherwise available except, for the most part, in the JOURNAL of this Association and in engineering periodicals.

The contents are: Part I — On the Methods and Principles of Developing, Improving, and Storing Water Supplies: Ground Water Supply; River-water Supply; Pumping Engines; Impounded Supplies. Part II — Maintenance and Operation: Plans and Records; Extensions; Service Connections; Meters; Care of Appurtenances; Alterations and Repairs; Maintenance of Quality; Water Waste; Electrolysis; Fire Protection; Accounts; Financial Management; Rules and Regulations; Annual Reports. Part III — Franchise: Water Rates; Depreciation.

Part I constitutes 217 pages, or more than half of the volume. It has to do almost wholly with the selection of sources of supply, their development and the filtration or other improvement of unsatisfactory waters, subjects previously treated by several writers, and, moreover, relating to matters of design and construction rather than of maintenance and operation of water works. Although the importance of these subjects is fully conceded and the excellence of their treatment in the present volume is not disputed, it seems to the reviewer that they are out of place in this book, or rather that the space devoted to them should not have exceeded 15 to 20 per cent., instead of 50 per cent., of the book.

Passing to Part II, "Maintenance and Operation," the part which gives the book its reason for existence, it is a pleasure to find so much valuable information, and, on the whole, so well arranged. It is out of the question, within the limits of this review, to give a more detailed statement of what the book contains than is presented in the above table of contents, and it may therefore be well to pass to a mention of what, in the reviewer's opinion, are some of the defects of the book.

In the first place, would it not have been wise to make a handbook or "pocket-book," similar to Trautwine, Kent, and Foster, instead of a book of such shape and bulk as to be convenient for library use only?

Although the paper is good and the type clear and sharp, the make-up may be criticised in several points. First and most important, there are practically no sub-headings, and even after looking up a reference in the index,— which, by the way, is a good one, — there is nothing to catch the eye and assist in finding the place. A freer use of bold-faced type and italics would have much improved the book in this particular. When tables or diagrams which are set lengthwise of the page are examined, it is found that some of them read up and others down. Some of the figures are on so small a scale as to render it difficult, if not impossible, to obtain the information which they are intended to convey — witness the cut of the Walker hydrant. Some of the half-tone cuts were made with so coarse a screen as to seriously impair the effect of the illustrations.

Some of the subjects not mentioned which appear well worthy of treatment are the following:

Forestry of watersheds; screens in intake gate houses; durability of asphalt in reservoir linings; anchor ice; painting; standpipes; ice in standpipes; selection of fuel; electrically-operated valves; hydraulic valves; check valves; valve chambers; fire service meters; the importance of measuring the quantity of water supplied to a distribution system, etc.

In spite of these defects, however, the book is a valuable one, and is certain to prove of much use to water-works men.

TRADE PUBLICATIONS.

Allis-Chalmers Company (Milwaukee, Wis.), *Pumping Engine Department.* BULLETIN NO. 1609, MARCH, 1907. *Official Duty Tests of Pumping Engines Nos. 1, 2, and 3, at Bissell's Point Pumping Station, St. Louis, Mo., Water Works.* Pp. 25. 8 x 10½ inches. Tables and illustrations.

These pumping engines are each of 20 000 000 gallons capacity, of the vertical triple-expansion type, with outside packed single-acting plungers. The tests were made in 1904 and 1905, and showed duties of 176 866 000, 176 094 000, and 181 068 605 foot-pounds, respectively, per 1 000 pounds of steam. The results of the tests are given in detail in the bulletin.

CAST-IRON PIPE. *Some Notes and Tables. Standard Specifications, Dimensions, and Weights of Cast-Iron Bell and Spigot Pipe and Special Castings for Water, Gas, Sewages, Culverts, Drains, etc. Flange Pipe and Special Castings, Flexible Joint Pipe, Loam Castings, Heavy Special Castings.* 1906. New York: United States Cast Iron Pipe and Foundry Company. Pp. 156. 8¼ x 10¾ inches.

This excellent handbook or catalogue contains considerable historical and descriptive matter relating to water conduits, especially cast-iron pipe, with many good illustrations. The standard specifications of the company are given. It is stated that "the standard specifications for cast-iron pipe and special castings will be found to be substantially those of the New England Water Works Association, modified to cover the four classes of pipe shown in our Table No. 2 instead of the ten classes listed in Table No. 2 of the New England specifications, while many of the dimensions in our Table No. 1 are identical with those of the New England Table No. 1." The greater part of the book is devoted to tables of dimensions and weights and other particulars relating to pipes and special castings, data which would be indispensable to any one laying out details of piping to be constructed with these standard castings.